MAY, 1958
No. 230

ASTM Bulletin

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American Society for Testing Materials

ASTM BULLETIN

May 1958 **Number 230**

Telephone: Rittenhouse 6-5315 **Cable Address: Testing, Philadelphia**

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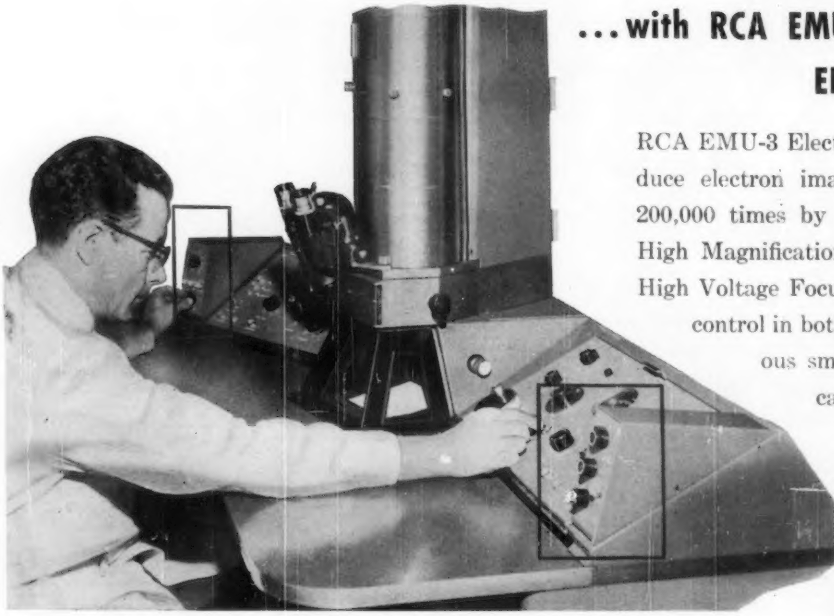

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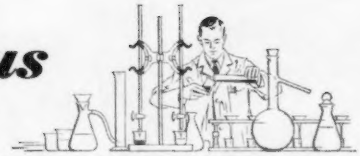

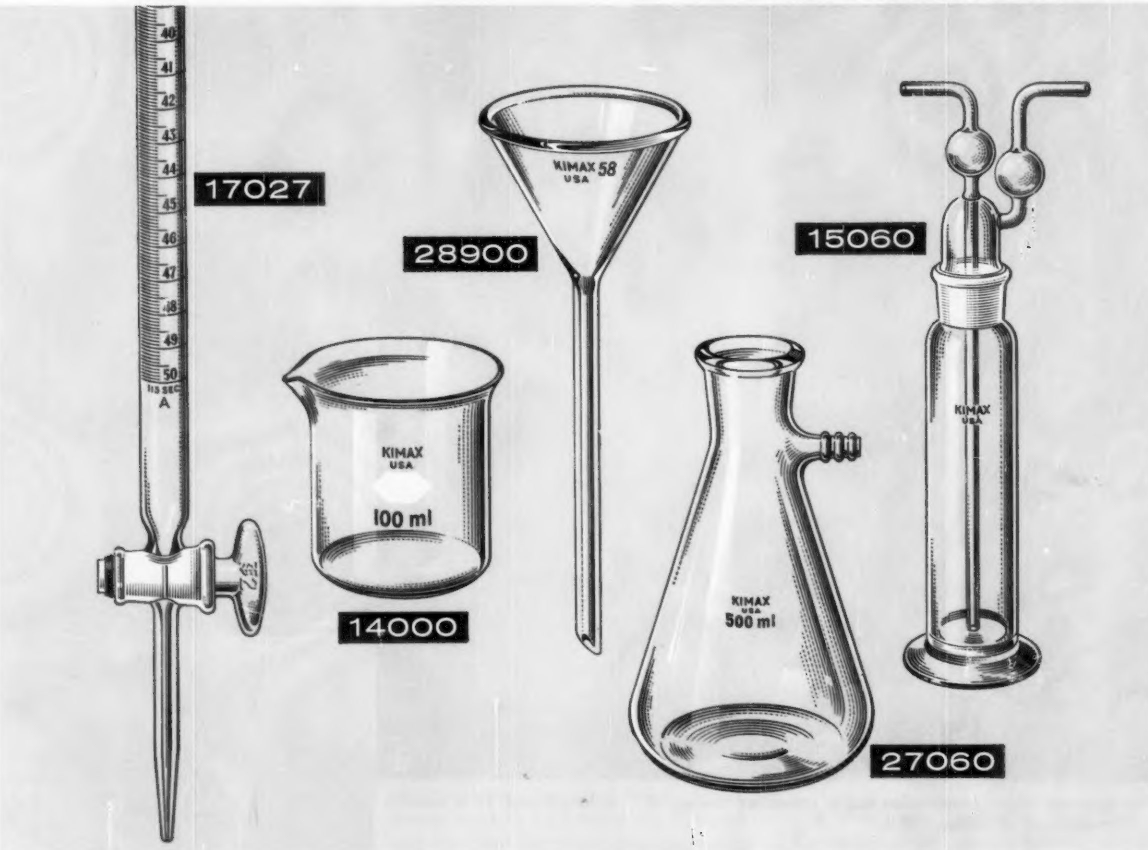

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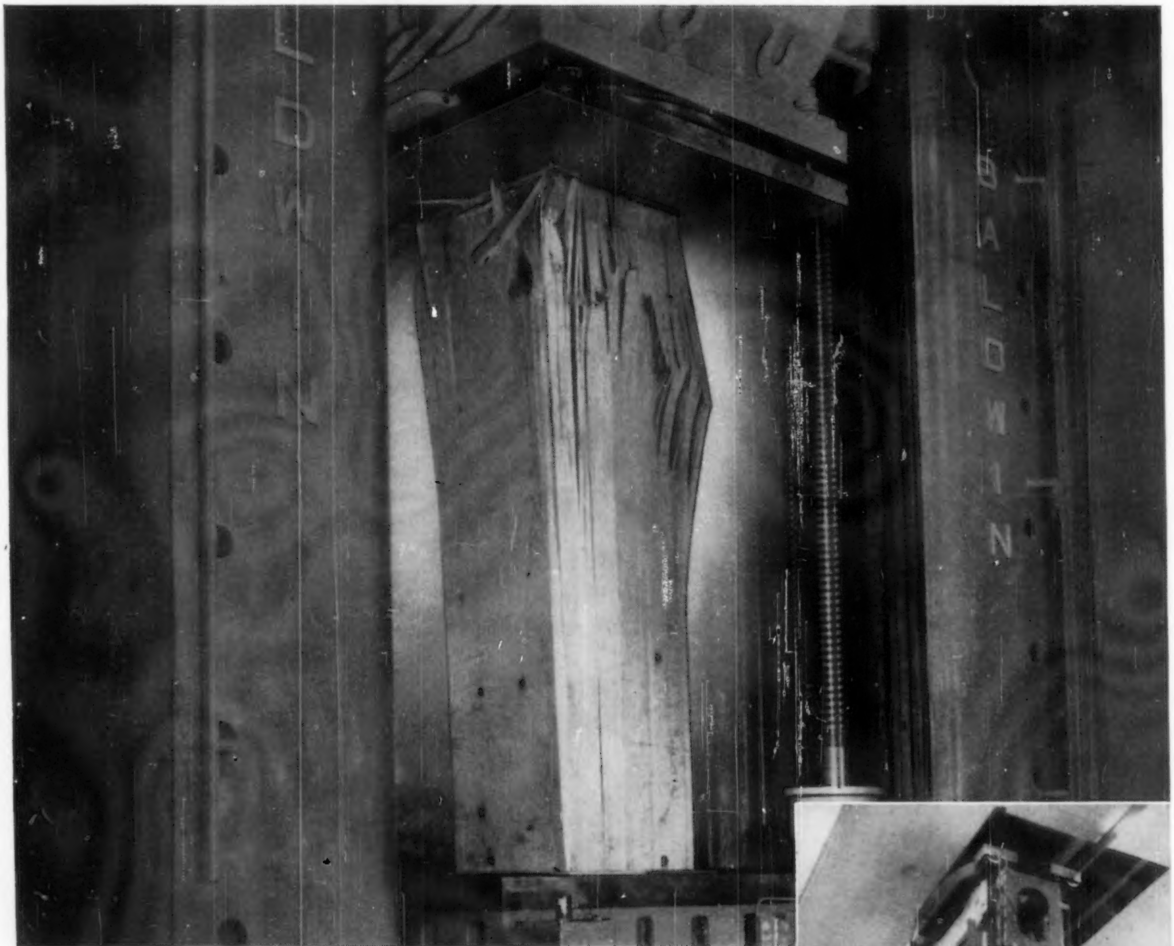
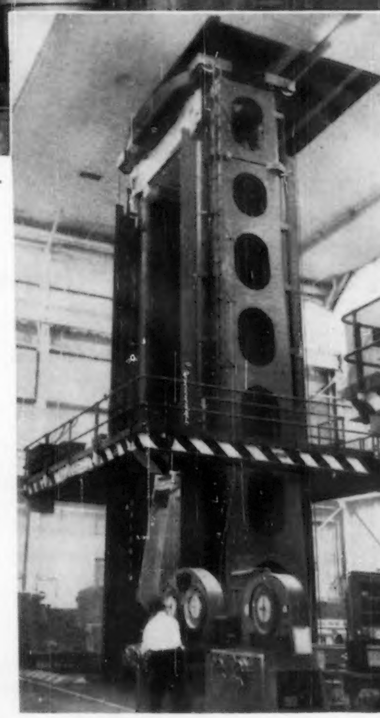


The specimen under compression test is laminated timber, 10 ft. in length and 30 in. square. Failure occurred at 4,840,000 lb.



Sixty-first Annual Meeting

BOSTON, MASS. • JUNE 22—27, 1958

Symposia on materials research—papers on materials—President's luncheon—awards and honorary memberships to be presented—four industry luncheons—apparatus and photographic exhibits.

Symposium on Materials Research Frontiers

Eight of the nation's leading scientists in research on engineering materials will relate the status of research on new engineering materials necessary for the space age. The speakers, all outstanding leaders in materials research, will discuss accomplishments in their respective fields that are helping to meet pressing challenges of the present and will assist us to prepare for the unfolding future.

Dr. Earl P. Stevenson, chairman of the board, Arthur D. Little, Inc., will speak on "Tailoring the Properties of Materials." Dr. Bruce H. Billings, vice president and technical director of Baird-Atomic, Inc., will discuss "Instruments in Materials Research." "Materials in the Nuclear Age" will be the subject of a paper by Dr. John J. Antal of the Watertown Arsenal. "Recent Advances in Polymer Research" will be discussed by Prof. Herman Mark, Department of Chemistry, Polytechnic Institute of Brooklyn. Arthur L. Lyman, president and director of research of the California Research Corp., will speak on "Modern Liquid Fuels." Dr. Walter R. Hibbard, manager of alloy studies, General Electric Co., will present a paper on "New Advances in Physical Metallurgy". "Recent Developments in Glass Research" will be discussed by Dr. W. W. Shaver, manager, Atomic Energy Research Dept., Corning Glass Works. Arthur von Hippel, professor of electrophysics, M.I.T., will present a paper on "Molecular Engineering."

This outstanding symposium is being organized and sponsored jointly by the Administrative Committee on Research and the New England District Council of ASTM with Walter J. Smith of Arthur D. Little, Inc., serving as chairman.

Medals and Awards to Be Presented

Several awards will again be made this year in recognition of outstanding technical papers and contributions to the Society. In previous years, these awards have been made during the Special Awards Luncheon. This year, however, the awards will be made at the following sessions:

The Award of Merit and Recognition of Fifty- and Forty-year Members will take place at the President's Luncheon at Tuesday noon at the Hotel Statler.

The Charles B. Dudley Medal, presented for a paper of outstanding merit constituting an original contribution on research in engineering materials; the Richard L. Templin Award, presented for a paper describing new testing methods and apparatus; and the Sam Tour Award, given for a paper of outstanding merit on corrosion testing, will be presented at the twenty-eighth session after the Marburg Lecture.

The Sanford E. Thompson Award, given for a paper of outstanding merit on concrete and concrete aggregates, and the C. A. Hogentogler Award, given for an outstanding paper on soils for engineering purposes, will be presented at the Road Materials Industry Luncheon at Wednesday noon at the Sheraton-Plaza Hotel.

The Max Hecht Award, given to a member of Committee D-19 of at least three years' standing in recognition of outstanding service to the committee in the advancement of its objective—the study of water as an engineering material—will be presented at the close of the thirty-eighth session devoted to the Symposium on Radioactivity in Industrial Water and Industrial Waste Water on Thursday evening at the Hotel Statler.

Industry Luncheons

The four industry luncheons being held at an Annual Meeting for the first time this year promise to be outstanding events. Full details were given in the April issue of the BULLETIN and members and visitors are urged to make their plans now to attend.

- Copper and Brass Industry Luncheon, Wednesday, June 25, Speaker: R. A. Wilkins, Vice-President, Revere Copper and Brass Inc., Rome, N.Y.

- Road Materials Industry Luncheons, Wednesday, June 25, Speaker: John A. Volpe, John A. Volpe Construction Co., Malden, Mass.

- Petroleum Industry Luncheon, Thursday, June 26, Speaker: Prof. Hoyt C. Hottell, Dept. of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

- Instrument and Apparatus Industry Luncheon, Thursday, June 26, Speaker: Dr. A. V. Astin, Director, National Bureau of Standards, Washington, D. C.

Technical Sessions at Two Hotels

It will be seen from the outline of technical sessions appearing on page 7 of this BULLETIN, that the sessions will be held in both the Hotel Statler (indicated (S)) and the Sheraton Plaza Hotel (indicated (P)). In general, we have attempted to place the technical sessions where they would be most convenient for our members attending committee meetings. This will enable our members to attend their necessary committee meetings and also the technical sessions of interest and, naturally, remain at the same hotel wherever feasible.

The Boston Meeting Planners

As we go into the final weeks of preparation for the Annual Meeting and look at the outstanding program that has been arranged for the interest and pleasure of ASTM members and their ladies, we are impressed by the tremendous amount of effort put forth by the officers and members of the General Committee on Arrangements and its subcommittees. Listed here are the officers and subcommittee officers who have done so much toward the success of the meeting:

Officers

H. J. Ball, honorary chairman, Lowell Technological Institute

Miles N. Clair, chairman, Thompson & Lichtner Co., Inc.

Emil A. Gramstorff, vice-chairman, Northeastern University

R. H. Doughty, vice-chairman, Fitchburg Paper Co.

R. P. Mahan, secretary, Baird Atomic, Inc.

William Moore, treasurer, J. P. O'Connell Co.

Subcommittee Chairmen

Miles N. Clair, Executive

F. J. Mardulier, Finance, Dewey & Almy Chemical Co.

William H. Buracker, Entertainment, Jackson & Moreland, Inc.

Mrs. Miles N. Clair, Ladies Entertainment

R. A. Pomfret, Promotion and Publicity, Bethlehem Steel Co.

A. G. H. Dietz, Technical Program, Massachusetts Institute of Technology

Junius W. Millard, Hospitality and Information, Quartermaster Research & Development Center

William L. Hyland, Transportation, Fay, Spofford & Thorndike

E. F. Walsh, Photographic Exhibit, Narragansett Electric Co.

Shuttle Bus Service

To eliminate as much inconvenience as possible to our members whose meetings might be held in more than one hotel, the Society will provide the services of a special Gray Lines bus which will make a continual circuit of the Statler, Sheraton-Plaza, and Bradford Hotels from 8 a.m. to 5 p.m., Monday to Thursday, and from 8 a.m. to 2 2 p.m. on Friday. This will mean that approximately every fifteen minutes the bus will stop at each hotel. Admission to this bus will be by registration badge.

Exhibit and Preprints

The Thirteenth Exhibit of Testing and Scientific Apparatus and the Photographic Exhibit will be held entirely at the Statler. It is hoped that our members will take every opportunity to visit these outstanding features of our meeting.

The distribution of preprints will be at the Hotel Statler *only*. It is quite evident that to attempt to distribute preprints from more than one point would be extremely difficult due to the large number of papers and reports that are available by selection. How to correctly divide our stock among three hotels would be a problem of higher mathematics, statistical analysis, and finally the crystal ball.

Ladies' Events

Monday

Coffee Hour at Hotel Statler, 10 to 11:30 a.m.

Shopping and touring "on your own"

Tuesday

Conducted Bus Tour—Historic Boston, Cambridge, Lexington and Concord with luncheon en route at the Wayside Inn—10 a.m. to 4:30 p.m.

Wednesday

Coffee Hour—10 to 11:30 a.m. **Tour of beautiful Gardner Museum** and afternoon tea at the Museum's Italian Garden—2:15 to 5 p.m.

Boston Pops Concert and Dinner at Boston Symphony Hall—6:45 p.m. (Concert 8:45 p.m.) An event for the whole family.

Thursday

Conducted Bus Tours—South Shore Trip to Plymouth, Quincy, and other historical points with luncheon at Hugo's of Cohasset on the Ocean—10 a.m. to 4:30 p.m. Or,

North Shore Trip to Salem, Swampscott, Saugus Iron Works and other historical points with luncheon at the Swampscott Ocean House—10 a.m. to 4:30 p.m.

Program Additions

In addition to the formal sessions and symposia announced in the April ASTM BULLETIN, the following committee-sponsored sessions will be held:

Symposium on Instrumentation, sponsored by Subcommittee IV on Instrumentation of Committee D-22 on Methods of Atmospheric Sampling and Analysis, will be held Monday, June 23, at 9:30 a.m.

Symposium on Stability of Distillate Fuel Oils, sponsored by Technical Committee E on Burner Fuel Oils of Committee D-2 on Petroleum Products and Lubricants, will be held on Wednesday, June 25, 9 a.m. to 5 p.m.

Symposium on Electron Microscopy—Particularly of Titanium and Related Metals, sponsored by Subcommittee XI on Electron Microstructure of Metals of Committee E-4 on Metallography, will be held Tuesday, June 24, at 9 a.m.

Changes in the Provisional Program

Since the appearance of the Provisional Program in the April ASTM BULLETIN, it has been found necessary to run the Symposium on Bulk Sampling in the afternoon as well as the evening of Monday, June 23. The papers by A. J. Duncan; B. A. Landry; and W. M. Bertholf will be presented in the afternoon session; the papers by W. E. Deming; and by R. S. Bingham, Jr., J. L. Gioele, and V. B. Shelburne will be presented in the evening session.

The reports of Committees A-7 and E-6 will be presented at the sixteenth session rather than the fifth.

You will notice on the outline of the program appearing on page 7 of this issue, that we are calling attention to the note which erroneously appeared in the Provisional Program that the Symposium on Solvent Extraction in the Analysis of Metals was being sponsored in cooperation with the Chemical Division of the American Society for Quality Control. This should have applied to the Symposium on Bulk Sampling.

High Temperature Session (Eighteenth Session)—Paper on "Properties of Cast Iron at Elevated Temperatures" by J. R. Kattus and Bryan McPherson, Southern Research Inst., added to session.

Crack Propagation Session (Twentieth Session)—Paper on "Correlation of Tests Using the Congruency Principle" by J. D. Lubahn, General Electric Co., added to session.

High Temperature Session (Twenty-second Session) and Non-Ferrous Metals (Twenty-fifth Session)—The paper on "A Study of the Variability in the Mechanical Properties of Grade A Phosphor Bronze Strip" by M. N. Torrey, G. R. Gohn and M. B. Wilk is being scheduled for the Session on Non-Ferrous Metals rather than the High Temperature Session. The paper on "The Effect of Atmosphere on Creep-Rupture Properties of a Nickel-Chromium-Aluminum Alloy" by Paul Shahinian and M. R. Achter is being scheduled for the High Temperature Session rather than the Session on Non-Ferrous Metals.

Symposium on Paper and Paper Products (Thirty-Sixth Session)—Paper on "A New Cotton Fiber Paper Furnish—Properties, Applications, Identification" by J. A. Harpham, Hercules Powder Co. added to this session.

Latest Information

This Program is subject to change

The complete advance program and abstracts appeared in the April issue of the Bulletin. The table below gives the outline.

Meetings at the Hotel Statler (S) and the Sheraton Plaza Hotel (P)

MONDAY, June 23	TUESDAY, June 24	WEDNESDAY, June 25	THURSDAY, June 26	FRIDAY, June 27
		MORNING		
1 **Opening Session—Session on Fatigue (S)**	9 **Session on Concrete (P)** 10 **Session on Fatigue (S)** 11 **Symposium on Radiation Effects on Materials (S)**	21 **Symposium on Materials Research Frontiers (P)** 22 **Session on High Temperature (S)** (Report Jt. Comm. Effect Temp.) —11:15 a.m.— 23 **Report Session (S)** (Reports B-1, B-2, B-5, B-8, B-9)	29 **Session on Soils (P)** 30 **Session on Cement (S)** 31 **Symposium on Particle Size Measurement (S)** —11:30 a.m.— 32 **Report Session (S)** Reports C-8, C-12, C-20, C-21, C-22, D-5, D-14)	39 **Symposium on Particle Size Measurement (S)**
	—12:00 noon— 12 **Luncheon Session, President's Address, 40- and 50-year members, Awards (S)**	—12:00 noon— **Road Materials Industry Luncheon (P)** **Copper and Brass Industry Luncheon (S)**	—12:00 noon— **Petroleum Industry Luncheon (S)** **Instrument and Apparatus Industry Luncheon (P)**	
		AFTERNOON		
2 **Symposium on Basic Mechanisms of Fatigue (S)** 3 **Symposium on Some Approaches to Durability in Structures (S)** 4 **Symposium on Solvent Extraction in the Analysis of metals[1] (P)** 5 **Symposium on Bulk Sampling[1] (P)** —4:30 p.m.— 6 **Report Session (S)** Reports A-2, A-9, C-2, D-7, E-5, E-11)	13 **Symposium on Radiation Effects on Materials (S)** 14 **Session on Textiles (S)** (Report D-13) 15 **Session on Road and Paving Materials (P)** —4:15 p.m.— 16 **Report Session (S)** (Reports A-5, A-6, A-7, A-10, B-7, C-4, C-7, E-6, E-12, F-1, Adv. Comm. Corrosion) —5:00 p.m.— 17 **Gillett Lecture (S)** **Clyde Williams** **High Temperature Metals for the Future**	24 **Symposium on Materials Research Frontiers (P)** 25 **Session on Non-Ferrous Metals (S)** —4:00 p.m.— 26 **Report Session (S)** (Reports A-1, B-3, B-6, D-1, D-9, E-4, E-10, Jt. Comm. on Leather) 27 **Report Session (P)** (Reports C-3, C-9, C-18, D-4, E-3) —4:30 p.m.— 28 **Marburg Lecture (S)** **E. W. Pehrson** **Man and Raw Materials**	33 **Symposium on Particle Size Measurement (S)** —3:00 p.m.— 34 **Symposium on Paper and Paper Products (S)** —4:30 p.m.— 35 **Report Session (S)** (Reports B-4, D-17, D-21, D-22, D-23, D-24, E-1, E-2, E-7, E-13)	—12:30 p.m.— 40 **Report Session (S)** (Reports A-3, D-2, D-3, D-10, D-11, D-12, D-16, F-2, D-20) 41 **Report Session (P)** (Reports C-1, C-11, C-13, C-14, C-15, C-16, C-19, D-8) —2:00 p.m.— 42 **Symposium on Applications of Soil Testing in Highway Design and Construction (P)** (Report D-18)
		EVENING		
5 **(Cont.) Symposium on Bulk Sampling[1] (P)** 7 **Session on Ferrous Metals (S)** 8 **Session on Concrete (S)**	18 **Session on High Temperature (S)** 19 **Symposium on Effect of Water on Bituminous Paving Mixtures (S)** 20 **Session on Crack Propagation (P)**	—6:45 p.m.— **ASTM Dinner** —8:45 p.m.— **Boston Pops Orchestra**	—7:30 p.m.— 36 **Symposium on Paper and Paper Products (S)** (Report D-6) —8:00 p.m.— 37 **Symposium on Applications of Soil Testing in Highway Design and Construction (S)** 38 **Symposium on Radioactivity in Industrial Water and Industrial Waste Water (S)** (Report D-19)	

[1] Preliminary program which appeared in the April issue of the ASTM Bulletin erroneously indicated that the Symposium on Solvent Extraction in the Analysis of Metals was being sponsored in cooperation with the Chemical Division of the American Society for Quality Control. This should have applied to the Symposium on Bulk Sampling.

NEW ASTM PUBLICATIONS

Symposium on Spectrochemical Analysis for Trace Elements

IN RECENT YEARS it has become more and more apparent that important scientific advances have been attained because analytical methods have been developed for estimating very low concentrations of certain elements. Today whole industries are greatly influenced by the ability to determine or control trace amounts of elements present in materials. These newly perfected techniques have found application in such diverse fields as medicine, animal nutrition, metallurgy, plant nutrition and geological exploration. Research in the semiconductor and transistor fields has shown the great importance of knowledge of the presence and concentration of elements present at extremely low levels in supposedly pure materials. In a similar manner atomic energy research has placed greater and greater demands upon the analyst to provide data concerning elements at concentration levels which a few years ago defied determination.

Because of this growing interest in trace analysis and because emission spectroscopy is one of the few methods available for analytical work at trace levels, this symposium was arranged for presentation of the Annual Meeting of the Society in 1957.

CONTENTS

Emission Spectrometric Determination of Oxygen in Metals—V. A. Fassel, W. A. Gordon, and R. W. Tabeling

Spectrographic Determination of Trace Elements in Metals—J. A. Norris

Trace Analysis by Means of Graphite Spark—J. M. Morris and F. X. Pink

Principles of Quantitative Biological Emission Spectrography—B. L. Vallee

Application of Emission Spectrography to Trace Element Analysis in Plant and Soil Samples—W. G. Schrenk

Spectrochemical Analysis for Trace Elements in Geological Materials—K. J. Murata

STP 221; 84 pages; hard cover; price $2.75; to members, $2.20.

Determination of Gases in Metals

THE DETERMINATION of gases in metals has become a problem not only to metallurgists and metals chemists but also to engineers in applied fields. The material covered should be of vital interest to those in the electronics, missiles, and aircraft industries.

This symposium presents five papers delivered at the 60th Annual Meeting, June, 1957. They give a comprehensive view of current methods together with pertinent discussions received subsequent to the presentation.

CONTENTS

Bromination-Carbon Reduction Method for the Determination of Oxygen in Metals—Maurice Codell and George Norwitz

Emission Spectrometric Determination of Oxygen in Metals—V. A. Fassel, W. A. Gordon, and R. W. Tabeling

Two Apparatus for the Determination of Gases in Metals—D. L. Guernsey and R. H. Franklin

Application of Vacuum Fusion to Gas-Metal Studies—W. G. Guldner and A. L. Beach

Oxygen Determination Using a Platinum Bath and Capillary Trap—W. G. Smiley

STP 222; 66 pages; hard cover; price $2.20; to members $1.85.

Knocking Characteristics of Pure Hydrocarbons

THIS PUBLICATION makes generally available the data of the knocking characteristics of pure hydrocarbons that have been developed under the American Petroleum Inst. Research Project 45. While this information was developed primarily for the API project, its usefulness will be expanded by its broader distribution.

The project has been a very extensive undertaking and has entailed a considerable amount of research work carried out at the Ohio State University in the preparation of hydrocarbons and at several research organizations equipped with engines to measure their knocking characteristics.

The objective of the project was to obtain samples of a wide variety of pure hydrocarbons and to relate their structures and physical characteristics with their respective knock limitations in engines. A variety of engine types and operation procedures were selected for this investigation because of the important effect of these variables on knock rating of the hydrocarbons.

STP 225; 96 pages; hard cover; price $6; to members, $4.80.

Elevated Temperature Properties of Weld-Deposits and Weldments

THIS BOOK should be of particular use to design engineers in the power, oil, chemical, and aircraft industries. This is the first publication that attempts to draw together in one place all the available elevated temperature data on steels and similar alloys as indicated by current good welding practice. This publication will help the designer to a better understanding of welding applications.

This report is one of a current series of ASTM *Special Technical Publications* summarizing properties of alloys at high temperatures. These are prepared under the auspices of the Data and Publications Panel of the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals.

STP 226; 228 pages; $8^1/_2$ by 11 inches; paper cover; price $5.50; to members, $4.40.

Paint, Varnish, Lacquer, and Related Products

Compilation of Standards, D-1

THIS publication has been compiled to collect all of the ASTM specifications, methods of test, and definitions pertaining to paint, varnish, lacquer, and related products so as to have them together in convenient form for industry. It supersedes the January, 1955 edition. It contains some 200 standards of which 27 are new, revised, or have had their status recently changed. Among these are standards for pigments, drying oils, paint driers, thinners, shellac, varnish, lacquer, traffic paint, bituminous emulsions, printing inks, putty, glazing and caulking compounds, weathering tests, naval stores, cellulose and derivatives, and miscellaneous specifications.

Through cooperation with the Federation of Paint and Varnish Production Clubs, some 61 standards in this publication have been approved also as Federation Standards. These are indicated by the Federation Number on the standards so approved.

D-1 Compilation; 900 pages; paper cover; price $8.25; to members, $6.60.

1956 Supplement to the

Bibliography and Abstracts on Electrical Contacts

THIS SUPPLEMENT covers the years 1955 and 1956. It brings the total number of references to nearly 2300. To assist the reader there is both an author and subject index.

This publication should have extensive interest for the researcher in the electrical contact field — electronics, communications, and utilities.

The original publication STP 56-G, covers the entire development in this field from 1835 to 1951. There are over 1,000 references and hundreds of abstracts with references to original sources, dates and page numbers in STP 56-G.

STP 56K; 44 pages, paper cover; price $1.75; to members $1.35.

Actions on Standards

The Administrative Committee on Standards is empowered to pass on proposed new tentatives and revisions of existing tentatives, and tentative revisions of standards offered between Annual Meetings of the Society. On the dates indicated below the Standards Committee took these actions:

CONCRETE PIPE

Tentative Specifications for Concrete Drain Tile (C 412 – 58 T) (Approved March 31, 1958)

New Tentative.—These specifications cover three classes of nonreinforced concrete drain tile with internal diameters from 4 through 24 in. as follows:

(a) Standard Quality Concrete Drain Tile intended for land drainage of ordinary soils where the tile are laid in trenches of moderate depths and widths. These tile are not recommended for internal diameters in excess of 12 in.

(b) Extra-Quality Concrete Drain Tile intended for land drainage of ordinary soils where the tile are laid in trenches of considerable depths or widths, or both.

(c) Special-Quality Concrete Drain Tile intended for land drainage where special precautions are necessary for concrete tile laid in soils that are markedly acid or contain unusual quantities of sulfates, and where the tile are laid in trenches of considerable depths or widths, or both.

THERMAL INSULATION

Tentative Method of Test for Hot Surface Performance of High Temperature Thermal Insulation (C 411 – 58 T) (Approved March 31, 1958)

New Tentative.—Many specifications for insulating materials state a minimum and maximum use of temperature. This method of test has been developed in order to have a means by which the maximum temperature may be determined.

RUBBER AND RUBBER-LIKE MATERIALS

Tentative Methods for Chemical Analysis of Synthetic Elastomers (D 1416 – 56 T) (Approved March 31, 1958)

Revision.—The ETA Extract Method has been included in order to provide a method for the determination of various organic constituents in synthetic rubber.

Tentative Recommended Practice for Nomenclature for Synthetic Elastomers and Latices (D 1418 – 56 T) (Approved March 31, 1958)

Revision.—Four codes and descriptions have been added to provide for Silicones which were inadvertently omitted in the original preparation of the recommended practice.

Tentative Methods for Testing Carbon Blacks in Rubber (D 1522 – 58 T) (Approved April 16, 1958)

New Tentative.—These methods apply to the procedures for testing carbon blacks when incorporated in rubbers. They may be used for checking the properties of blacks being produced by the manufacturers or for testing shipments of blacks as received by a consumer. All comparisons of physical properties are to be made with a reference black.

Tentative Specifications for Non-Metallic Gasket Materials for General Automotive and Aeronautical Purposes (D 1170 – 54 T) (Approved April 16, 1958)

Revision.—These specifications have been rewritten and brought up to date with current practice.

Tentative Recommended Practice for Description of Types of Styrene-Butadiene Rubbers (SBR) (D 1419 – 56 T) (Approved April 16, 1958)

Revision.—A new SBR Rubber assigned the permanent number 1805, has been added to Table II.

Tentative Recommended Practice for Description of Types of Styrene-Butadiene Latices (SBR) (D 1420 – 56 T) (Approved April 16, 1958)

Revision.—Three new latices have been added to Table I, to which permanent numbers have been assigned.

MATERIALS FOR ELECTRON TUBES AND SEMICONDUCTOR DEVICES

Tentative Method of Test for Volatile Content of Germanium Dioxide (F 5 – 58 T) (Approved March 31, 1958)

New Tentative.—A method to determine the germanium content of the oxide is needed, especially since germanium dioxide is a very expensive material.

Tentative Method of Test for Bulk Density of Germanium Dioxide (F 6 – 58 T) (Approved April 15)

New Tentative.—Germanium oxide is bought in powder form and the apparent density is an important physical property in processing the powder to elementary germanium.

STEEL

Tentative Specification for Welded and Seamless Steel Pipe (A 53 – 57 T) (Approved April 16, 1958)

Revision.—The revision permits steel made by the basic oxygen process to be furnished under these specifications.

FILLER METAL

Tentative Specification for Mild Steel Arc-Welding Electrodes (A 233 – 55 T) (Approved March 31, 1958)

Tentative Specifications for Low-Alloy Steel Covered Arc-Welding Electrodes (A 316 – 54 T) (Approved March 31, 1958)

Revision.—These specifications were revised in order to bring them up to date with current industry practice.

NSF Issues Lab Directory

The publication "Directory of Independent Commercial Laboratories Performing Research and Development, 1957" by the National Science Foundation is the most recent available listing of this type of laboratory and its activities.

The directory lists 565 laboratories, together with names of senior officers, numbers of research staff, and types of research activities.

Copies may be purchased for 40 cents from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

ASTM Bulletin

MAY 1958

NO. 230

NINETEEN-SIXTEEN
RACE STREET
PHILADELPHIA 3, PENNA.

Centigrade or Celsius?

Words are wonderful things. We cannot communicate without them and yet how much confusion can result from differences in usage or interpretation. So we find it today with that well-known name of a temperature scale, "Centigrade" which the Ninth General Conference on Weights and Measures decided in 1948 to officially change to "Celsius." The National Bureau of Standards has adopted the use of "Celsius" in its publications and has assumed the task of promoting the use of this new name in the United States. It has in turn asked the ASTM to give it active support.

What's wrong with Centigrade? Why is there any confusion? It was firmly entrenched when I went to school—why not now? What does Celsius have to offer to make it better?

The so-called Centigrade temperature scale was conceived by the Swedish astronomer Anders Celsius a little over 200 years ago. He chose the melting point of ice as one end of his scale, the boiling point of water as the other and divided the interval between these fixed points into 100 equal parts or degrees. These two fixed temperatures have long served as fundamental points on our scales of temperature, but at a meeting preliminary to the Ninth Conference on Weights and Measures it was suggested that the triple point of water which has a temperature of 0.01 C would be a better fixed point that the ice point. If assigned a definite value, it could serve as the basis of the thermodynamic scale, a desirable feature from the theoretical viewpoint.

The problem of words then reared its ugly head. If the triple point were to replace the ice point the fundamental interval between it and the steam point would be 99.99 degrees. This would hardly be in keeping with the designation Centigrade which means "consisting of a hundred degrees." The French compounded the confusion by pointing out that "centesimal" might very well be used in place of "Centigrade." From all this came the happy suggestion "why not do as has been done for all other temperature scales in common use, name it for its inventor, Anders Celsius." It would then fit in with Kelvin, Reamur, and Fahrenheit. The Ninth General Conference adopted this proposal thus making the change an official one.

Acceptance of this new name has been very slow in the United States, although quite the opposite is true in other countries. Travelers to Europe today will find Celsius in common usage and our scientific colleagues in other countries are actively using this new term. In order to smooth the transition it is suggested we use "Celsius (Centigrade)" in our writings. The abbreviation "C" would continue to be used which, of course, eases the blow considerably.

It has been proposed to ASTM Committee E-1 on Methods of Testing by Subcommittee 17 on Thermometers that ASTM take the initiative among technical and scientific societies and adopt this change in terminology. What is your opinon?

R. D. Thompson

Schedule of ASTM Meetings

This gives the latest information available at ASTM Headquarters. Direct mail notices of all district and committee meetings customarily distributed by the officers of the respective groups should be the final source of information on dates and location of meetings. This schedule does not attempt to list all meetings of smaller sections and subgroups.

Date	Group	Place
June 2-6	Committee E-14 on Mass Spectrometry	New Orleans, La. (Hotel Jung)
June 18	Committee D-25 on Casein and Similar Protein Materials	Lancaster, Pa.
June 22-28	**Annual Meeting**	**Boston, Mass. (Statler and Sheraton Plaza Hotels)**
Sept. 24-26	Committee E-14 on Mass Spectrometry, and Mass Spectrometry Panel of British Institute of Petroleum	London, England (Univ. of London)

Executive Secretary Recovering from Hip Operation

On March 5 in Chestnut Hill Hospital, Executive Secretary Painter underwent an arthroplasty of his left hip, which involved the rebuilding of the hip joint with a precision cast vitallium ball and shaft. Everything has gone along normally and, as this issue goes to press, he is attending the meetings of the Board of Directors on May 12 and 13 at the Headquarters office and expects to get to the Annual Meeting.

Meanwhile a good deal of Society business has been conducted, especially during the period of physical therapy, in his quarters at All Saints Episcopal Hospital in Chestnut Hill.

It had been apparent for quite a period that some remedial surgery would be necessary to repair the damage in the hip caused by osteoarthritis, and the logical action was the vitallium joint.

The Executive Secretary wishes to thank his many friends and associates in the Society who have remembered him while in the hospital.

The *Indian and Eastern Engineer* 100 Years Old

The *Indian and Eastern Engineer*, the oldest and only engineering journal of its kind in India and the Far East is now in its 100th year, according to a recent letter from Mick de Souza, executive editor and general manager. Our congratulations on 100 years of service to the engineering profession!

ACR NOTES

Administrative Committee in Research

Waste in Committee Research

By BRUCE W. GONSER[1]

RESEARCH in its broadest sense is fact finding. On that basis practically every specification of the ASTM has had to depend upon some research for its foundation and for many of the changes that keep it up to date. Yet how much of this research is lost through lack of proper publication!

One of the responsibilities of the Administrative Committee on Research is to encourage publication of the results of the many investigations that are constantly in progress in ASTM. This is not difficult to do when a symposium is involved or an organized technical program is being arranged. Here, the program chairman and his committee usually solicit papers that fit the meeting. Occasionally, spontaneous articles appear, but all too rarely. The really difficult job is to bring to light results of an investigation that some committee has had to undertake in order to write a reasonable specification.

There are several reasons for this reluctance to publicize committee investigations. One is the divided authority that committee work represents. Too often no one wants to take the responsibility or the bother of gathering together the threads of an activity that may spread over several years and write it into an acceptable article. Almost always, there is a bit of doubt as to the value of the work to those outside a specialized task group or subcommittee. Then, too, there is the evil of inertia when an investigation continues beyond the time when some of the results are used by the committee and no one knows quite when, if ever, the work will be finished.

Naturally, not all investigations undertaken by ASTM committees are worthy of publication. If in doubt, it would be well to ask the advice of Headquarters. The Staff may get a broader view of a specialized piece of work and be in a better position to judge its importance from the Society standpoint than those who actually have done the investigation. The main thing is to give them, or someone, a chance to say "yes" or "no." The tragedy with so many committee activities is that a lot of work is done; hundreds, and perhaps even thousands, of man hours of activity go into gathering facts from which a specification or important specification change is made; then many of the results are lost through failure to write up the investigation into a permanent form.

One of the most important advantages of publishing the results of an investigation that leads to a specification is to give some reasons why a certain analysis or property or designation is made. Once a specification is published and accepted and used, it tends to become somewhat sacred. One hesitates to request a change when the unspoken inference is that each designation and phrase has been debated over and over and a final decision reached only after great care. It is possible that a point in the specification is made through lack of information rather than through a conclusive investigation. Contrariwise, in reviewing a specification, some point is frequently questioned and possibly changed because no one on the new task group or subcommittee happens to remember the data or the arduous debating and painful compromises that went into the selection of this particular value.

Along with publication of results of committee investigations in a place where they can be found readily is the desirability of using pertinent references in specifications. It seems sensible to give those who must follow the specification some hint as to the source of technical information used in selecting important or debatable points. This is something for ASTM members to consider. It is of sufficient importance, however, to justify a complete, separate treatment rather than a passing comment in a plea for avoiding waste in research effort by publicizing results.

[1] Technical director, Battelle Memorial Institute; chairman, Administrative Committee on Research.

To the Editor

Keeping Abreast of the Literature

I should be grateful for space to express my surprise—not to say astonishment—at some of the statements made by Mr. Frank T. Sisco in your issue for December, 1957.[1]

In this country we do not feel quite so overcome by the problem.

Within the space of a letter I will not attempt a detailed discussion of Mr. Sisco's jeremiad. If, however, his statement that probably less than 25 per cent of the available literature is abstracted in any one year refers to metallurgical subjects then it is in irreconcilable conflict with our own experience and observation.

"No library, so far as I know, has the available staff, either in numbers or in skills, to index and classify periodical literature so that they (sic) can be delivered to the specialized reader on demand, or even in a 'reasonable time.'" I can only assume that, in making this statement, Mr. Sisco is confining himself to conditions in the United States—although he does not so confine himself when dealing in the preceding paragraph with abstracting services.

If Mr. Sisco is ever in this country I should be happy to show him the library of this Research Association, which does precisely those things that Mr. Sisco has never encountered. And our library is only one of many such units maintained by the British Research Associations. Most of these libraries, as we do, issue an abstract journal. As to coverage, speaking for ourselves, we aim at 100 per cent coverage in our own special field and in six years have had no evidence that we fall so very far short of this.

Yours faithfully,
Wm. E. Fuller,
Information Officer,
British Steel Castings
Research Association

[1] Frank T. Sisco, "ACR Notes—The Problem of Using Available Engineering Knowledge," ASTM BULLETIN, No. 226, December, 1957, p. 9.

Author's Reply

I was amazed to learn from Mr. Fuller's letter that in abstracting the metallurgical literature in the field of steel castings his organization "aims" at 100 per cent coverage of [its] own specific field and in six years [it] has had no evidence of falling very far short of this." This is a remarkable performance. It certainly is not equaled by any abstracting service in any broad field of engineering in the United States, and I question if it is equaled by any other

such service elsewhere in the world. It certainly is not equaled by the excellent abstracting services of the Institute of Metals and the Iron and Steel Institute of Great Britain, both of which I have gone over item by item and month by month for many years.

I will admit that my statement that probably "less than 25 per cent of the available literature [in engineering] is abstracted in any one year" was a guess, but it was an educated guess based on a Library of Congress survey, which stated that in 1952 it received 40,000 technical and scientific journals containing 1,500,000 papers, and my knowledge of the number of engineering journals and reports received by the Engineering Societies' Library in New York and the number of abstracts published annually by Engineering Index, which covers all these journals. It was further based on the number of journals abstracted by the Institute of Metals and the Iron and Steel Institute of Great Britain and by the American Society for Metals with the cooperation of the John Crerar Library of Chicago. Considering the data available to me when I prepared my original paper for the National Research Council about a year ago, and more recent information, I am now convinced that my estimate of 25 per cent coverage of engineering literature is probably somewhat high.

Mr. Fuller objects to my statement that "no library has the staff. . .to index and classify the periodical literature." This is true for the United States, at least for libraries which receive more than 1000 periodicals monthly, and I am sure that it is true for all other libraries in the world unless they are very small. The Engineering Societies' Library tried it for 14 years, from 1929 to 1943, financed by gifts from industry. It cost approximately $4000 a year, which is too much to be justified by prospective use, and the attempt was discontinued. About 300,000 abstract cards were prepared, or about 20,000 a year. However, the classification was made by a librarian and not by an engineer, and consequently it left much to be desired in accuracy and completeness. I know, because I attempted to use it for metallurgy.

I have personally been working with indexes and abstracts of the world's periodical literature, in the field of alloy steels and cast irons, for many years, and I feel that every statement made in December, 1957 ACR Notes was justified by my own experience. I would be delighted to learn more about Mr. Fuller's perfect abstracting service, and it would be a pleasure to exchange experiences with him personally.

Frank T. Sisco

ASTM Wood Pole Research Program

Progress Report No. 6[1]

Editor's Note.—**This report is the sixth of a series covering the comprehensive testing program being conducted at the Forest Products Laboratory under the sponsorship of Committee D-7 on Wood. The previous reports have been published in the ASTM Bulletin and copies may be obtained on request.**

With the testing of a 30-ft Class 6 western larch pole at the Forest Products Laboratory on February 4, 1954, the extensive ASTM Wood Pole Research Program that had been under development by Committee D-7 on Wood for several years got under way. Now, four years later the program as outlined is in its last phase and is nearing completion.

The program involves the testing of full-size poles of five species in both the untreated and treated condition. Tests were also included to compare the results obtained by the cantilever method with those by the machine test method. In all, the program covers tests of some 600 full-size poles and some 15,000 tests of small specimens to evaluate the properties of the clear wood. The principal purpose has been to obtain basic data on the relative strength of species in the form of full-size poles, both treated and untreated, and to correlate the results with tests of small clear specimens as a basis for developing specifications and design stresses.

The work has been supported by contributions from numerous interested pole producers, pole users, and public agencies, and the testing work has been conducted by the Society with the cooperation of the Forest Products Laboratory. The details of the program have been guided by a Technical Advisory Committee of Subcommittee VII on Wood Poles and Cross Arms of ASTM Committee D-7 on Wood.

Progress to Date

It has been the procedure as the work progressed to prepare interim reports covering the results of the tests for each phase of the program. These are distributed to members of the subcommittee and to contributors to the program. On completion of the program the final report will be made generally available in published form. To date nine interim reports have been completed and distributed as follows:

1. Tests of Untreated Western Larch Poles.
2. Tests of Untreated Southern Yellow Pine Poles.
3. Tests of Untreated Douglas-Fir Poles.
4. Tests of Untreated Lodgepole Pine Poles.
5. Tests of Untreated Western Redcedar Poles.
6. A Comparison of ASTM Wood Pole Test Methods Based on Tests of Untreated Southern Yellow Pine.
7. Supplement to the Report—"Tests of Untreated Lodgepole Pine Poles."
8. Tests of Treated Southern Yellow Pine Poles.
9. Tests of Treated Douglas-Fir Poles.

Two other interim reports are now being reviewed and will be forthcoming shortly as follows:

1. Tests of Treated Western Larch Poles.
2. Tests of Treated Lodgepole Pine Poles.

These reports provide a wealth of technical data on poles that has long been needed as a basis for improved specifications and a more rational basis for design. It has been the practice in the preparation of these reports to present the data in detail but without attempting to analyze the results in terms of effect of various factors on strength and without drawing conclusions. The last step of the program will involve the analysis and interpretation of all of the data, integrating it into a final comprehensive report for publication and wide distribution. As far as possible, available data on related phases of factors affecting the strength and utility of poles will also be incorporated to make this as complete a compilation as possible.

Current Work

The tests of the full-size treated western redcedar poles in the 30- and 25-ft series have been completed. Only five full-size poles of this species remain to

[1] Progress Report No. 5 appeared in the September, 1957 ASTM Bulletin, p. 16.

be tested by the cantilever method. Work presently under way involves completing the tests of small clear specimens of this species, the computation and compilation of the data from the tests of full-size poles and small clear specimens, and the preparation of the interim report for this species.

Consideration is already being given to the final phase of the program which involves the critical review, analysis, and integration of all of the data into a final report including interpretation of the results and conclusions. Because of the extensive data available and the careful analysis required, this phase involves a great deal of technical time. As near as can be estimated, with continuing effort the project as originally outlined will be completed about the end of 1958.

Supplementary Research Program

It was recognized that one of the problems confronting the committee in directing the work was that of adhering to the basic program originally outlined without including a number of phases of important supplementary work that appeared desirable. Examples of phase that could not be included were the effect of defects on strength, studies of the twisting of poles as a result of spiral grain, machine *vs.* hand peeling, full length *vs.* butt soaking, and the effect of various preservative treating methods that might be employed with each of the species. It was recognized that these that might be employed with each of the species. The work has been carefully confined to the scope of the original program. It was recognized that these additional problems might later be evaluated in accordance with their importance, and if needed, supplementary programs established.

In the analysis of the data on treated southern yellow pine, it was brought out that the particular standard American Wood-Preservers' Assn. treatments employed, with respect to temperature and pressure, were such as to result in a substantial loss of strength beyond what was felt desirable to accept as good practice in line with the efficient strength utilization of this important pole species. Following discussion of the problem at a meeting of the Technical Advisory Group at Madison in March, 1957, a task group was appointed under the chairmanship of Ralph H. Bescher to study the problem.

The committee agreed that it should be possible to obtain satisfactory treatment of southern pine poles without incurring the losses of strength observed in the ASTM Wood Pole Research Program, and recommended further research on the subject. Because the proposed research was over and above the original ASTM Wood Pole Research Program and yet related to it, it was agreed to recommend it as a supplement to that Program under the designation ASTM Pole Research Program No. 2. Because the results related to southern pine and are of special interest to the producers and treaters concerned with this species, it was further recommended that this program should be underwritten independently of the main program.

A two-part research program was developed. The first part consists of plant experiments to show if satisfactory penetration and distribution of preservative is obtainable with milder schedules than the maximum under current AWPA standards. The second part consists of strength tests of full-size treated poles and small clear specimens to show if the milder schedules will have less effect on strength. The first part of the program is about half done. Test material for the second part has already been selected and treated, and the tests will be started in the near future. The estimated cost of this supplementary program of $30,000 has already been underwritten.

Financial Statement

Originally the ASTM Wood Pole Research Program was planned for a 2-year period, but it soon became apparent that because of the extent of the work it could not be completed in this time. Further, it was apparent that additional time was needed for underwriting the cost of the work. Contributions were accordingly invited over a period of years.

Contributions to the program as of February 28, 1958, were $256,980.94. Total expenditures to the same date were $239,384.31. The estimated cost of the work will somewhat exceed $260,000. On this basis something over $20,000 is required for the completion of the program, $17,596.63 of which is now available as a balance of funds already contributed. Some further contributions are invited to assure the satisfactory completion of the program and the final report.

Committee D-7 on Wood wishes gratefully to acknowledge the support of the large number of contributors that have made this program possible.

L. J. Markwardt, Chairman
Committee D-7 on Wood

Second Conference on

Analytical Chemistry in Nuclear Reactor Technology

The Oak Ridge National Laboratory has announced that the second in a series of unclassified meetings on the role of Analytical Chemistry in Nuclear Reactor Technology will be held in the Civic Auditorium at Gatlinburg, Tenn., on September 29, 30, and October 1, 1958. This meeting is a continuation of the first conference which was also held at Gatlinburg in November, 1957. (See news account in the December, 1957 issue of *Analytical Chemistry*.)

The first conference dealt specifically with reactor materials. At the forthcoming conference, it is intended to continue these discussions but with emphasis on analyses required prior to the start-up of nuclear reactors and similarly to the same functions as may be applicable during reactor operations. Analytical chemistry as it pertains to post-operational activities is believed to be a matter of sufficiently broad interest and scope to warrant the holding of separate, future conferences on this aspect alone.

It is intended that the program will be contributory, and any worker in the field who feels that he has some worthwhile contribution to offer is encouraged and invited to participate in the program. Papers of any length which may require up to 30 min for presentation will be considered. Abstracts of approximately 200 words should be submitted by July 1. Publication of the proceedings is anticipated and copies of all manuscripts received prior to October 1 will be included in the publication.

For further information concerning the details of this meeting and for the submission of contributions and abstracts of papers, please write

C. D. Susano
Oak Ridge National Laboratory
P. O. Box Y
Oak Ridge, Tenn.

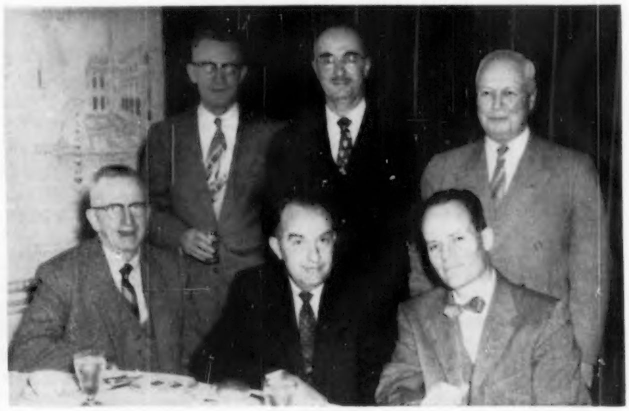
Magnetic Materials Conference

The fourth Conference on Magnetism and Magnetic Materials will be held in Philadelphia, November 17–20, 1958, at the Sheraton Hotel. This conference is sponsored by the American Institute of Electrical Engineers in cooperation with the American Physical Society, the Institute of Radio Engineers, the Metallurgical Society of A.I.M.E., and the Office of Naval Research. Authors should submit titles of proposed papers by August 1 and abstracts by September 1 to the program chairman, H. B. Callen, department of physics, University of Pennsylvania, Philadelphia, Pa. Further details may be obtained from C. J. Kriessman, local chairman, Remington Rand Univac, 1900 W. Allegheny Ave., Philadelphia.

General Committee on Arrangements 1959 Pacific Area Meeting

Third of a series of National Meetings of the Society in the Pacific area, the 1959 meeting will be held in San Francisco the week of October 11. Already, this enthusiastic group of ASTM members on the coast is laying plans for an outstanding meeting, both for technical program and for entertainment. This will be the second National Meeting in the Golden Gate City and the third on the West Coast.

Left to right (standing): L. A. O'Leary, W. P. Fuller & Co., treasurer of general committee and chairman of finance committee; P. E. McCoy, American Bitumuls and Asphalt Co., vice-chairman of general committee; and G. J. Grieve, Pacific Paint & Varnish Co., chairman, technical program committee; (seated) Theo. P. Dresser, Jr., Abbot A. Hanks, Inc., honorary chairman of general committee; P. V. Garin, Southern Pacific Co., chairman of general committee; H. P. Hoopes, Fibreboard Paper Products Co., secretary of general committee.



Left to right (standing): Roy Henning, Eitel-McCullough, Inc., chairman, industry luncheons committee; R. C. Vollmar, Standard Oil Company of California, vice-chairman, technical program committee; C. F. Lapier, Matson Navigation Co., chairman, transportation committee; R. A. Kinzie, Jr., Pacific Cement and Aggregates, Inc., vice-chair man, transportation committee; H. de Bussieres, Curtis & Tompkins, Ltd., vice-chairman, social committee; R. W. Harrington, Clay, Brick & Tile Assn., chairman, social committee; (seated) E. V. Noe, Pacific Gas & Electric Co., chairman, plant visits committee; Dozier Finley, Research Consultant, general chairman, First Pacific Area National Meeting, 1949; E. W. Gardiner, California Research Corp., vice-chairman, finance committee.

Members of the committee not shown above are: R. E. Davis, University of California, honorary vice-chairman; W. C. Hanna, California Portland Cement Co., honorary vice-chairman; C. M. Wakeman, Los Angeles Harbor Dept., honorary vice-chairman; M. B. Niesley, California Testing Labs., Inc., vice-chairman; Jenmore Dickason, Metal Control Labs., Inc., vice-chairman, finance committee; Ernst Maag, California State Dept. of Public Works, vice-chairman, technical program committee; T. K. Cleveland, Phila. Quartz Co. of Calif., chairman promotional and publicity committee; R. N. Conner, Baldwin-Lima-Hamilton Corp., vice-chairman, promotional and publicity committee; F. W. Twining, Twining Laboratories, vice-chairman, promotional and publicity committee; Don Bowers, General Petroleum Corp., chairman, industry luncheons committee; M. C. Poulsen, Port Costa Brick Works, vice-chairman, plant visits committee; W. W. Moore, Dames & Moore, chairman, hotels committee; R. C. Kennedy, East Bay Municipal Utility Dist., vice-chairman, hotels committee; J. H. Dunn, Hersey Inspection Bureau, chairman, information committee; G. F. Scherer, Rockwell Mfg. Co., vice-chairman, information committee.

Technical Committee Notes

Chemical-Resistant Mortars

Significant Properties: Weight Loss, Compressive Strength

The weight loss of various chemical-resistant mortars in chemical solutions and solvents is a significant property for which Committee C-3 on Chemical-Resistant Mortars, which met at ASTM Headquarters on April 1, has developed a test procedure. The significance of this relatively rapid test to evaluate partially the chemical resistance of various resin mortars is to serve as a guide in, but not be the sole basis for, the selection of a mortar for a particular application. Along with the weight change, the appearance of the sample and the appearance of the test solution are also observed as part of the evaluation of the test results. Compressive strength will also be considered a significant property in the evaluation of chemical resistance and a method of test will be prepared.

Additional physical properties for which test methods are being developed include thermal expansion and shrinkage. The flexural strength of chemical-resistant mortars will soon be covered by a proposed method now in its final draft.

Present recommended practices covering each of the four types of mortar under the jurisdiction of Commitee C-3 will be reviewed for the purpose of making their contents more uniform. In particular, the tentative recommended practice for use of hydraulic cement mortars in chemical-resistant masonry (C 398) will receive careful review by both the Subcommittee on Hydraulic Mortars and the Subcommittee on Recommended Practices in light of suggested revisions submitted from the ceramic tile industry. The mortar mix proportions recommended for the setting bed will receive particular attention.

Officers elected for a two-year term are J. R. Allen, E. I. du Pont de Nemours & Co., Inc., chairman; W. H. Burton, General Chemical Division, Allied Chemical and Dye Corp., vice-chairman; and E. A. Reineck, Quaker Oats Co., secretary. Members at large elected to the Advisory Subcommittee are Beaumont Thomas, Stebbins Engineering and Manufacturing Co.; F. H. Buckley, E. I. du Pont de Nemours & Co., Inc.; and W. A. Severance, The Ceilcote Co.

Natural Building Stones

New Emphasis on Performance and Tests

Specifications for natural building stone based on quality of the material continue to be the primary objective of Committee C-18 on Natural Building Stones, which met in Washington, D.C., on April 17. It is felt this type of standard specification will provide the architect and engineer with a national standard which will ensure the proper performance and use of this type of material in building construction. The ASTM type of specification will provide requirements based on physical properties, the values for which can be determined by standard methods of test, thus getting away from the old established procedure of selecting natural building stone by name and source only.

Structural granite was the subject of the second in a series of specifications approved by the committee for letter ballot. The first already accepted by the Society, was for Roofing Slate. The specification for structural granite is based on a relationship between compressive strength and per cent of wear as a criterion of durability, and classified into life expectancy of less than and more than fifty years. There are gradings for specific use, covering both engineering and architectural grades.

A specification for exterior marble was reviewed, and suggestions were made for revisions which will make it more acceptable to the committee. The properties of absorption and bulk specific gravity, modulus of rupture, compressive strength, and abrasion resistance of the material subjected to foot traffic are the significant properties upon which the specification is based. There remain two additional types of building stone—sandstone and limestone—for which the committee hopes to develop specifications.

Textiles

Wash and Wear Terms Defined

The development of many new synthetic fibers, some having quite remarkable properties in their ability to take washing and drying without ironing, have introduced new problems in terminology. What is meant by such terms as machine-wash—tumble-dry, line-dry; and hand-wash—drip-dry? At its Washington meeting in March, Committee D-13 on Textiles tackled these problems of terminology and came up with these proposed definitions that are being considered in a subcommittee ballot:

Wash-and-Wear (*Wash-Wear*), *adj:*

1. General. A generic term applied to fabrics and to garments that will satisfactorily retain their original neat appearance after repeated wear and home laundering with little or no pressing or ironing.

NOTE 1.—"Retain their original neat appearance" means that the garment will retain any original pressed-in creases or pleats and be essentially free from undesirable wrinkles both during wear and after laundering. The garments should meet normal consumer demands for such properties as durability, color stability, shrinkage, etc.

NOTE 2.—The wash-and-wear performance of fabric or garment depends on several factors including the types and amounts (percentages) of fibers used, the fabric construction, the finishing treatment, the presence of a colored pattern (either woven or printed) and the methods used for washing and drying. All of these factors contribute to the over-all performance and determine, in any specific instance, how closely a fabric or garment will approach perfection. This situation shows up in the variable behavior of a specific fabric or garment under different conditions and is reflected in the use of specific commercial terms such as the following.

2. Specific. (*a*) Machine-wash, tumble-dry—A term applied to a variety of fabrics or properly fabricated garments which can be laundered in domestic type washing machines with regular centrifuging (spinning) followed by tumble drying. This is frequently termed "automatic wash-and-wear."

(*b*) Machine-wash, line-dry—A term applied to a variety of fabrics or properly fabricated garments which can be laundered in domestic type washing machines with suitable water extracting followed by line drying.

(*c*) Machine-wash, drip-dry—A term applied to a variety of fabrics or properly fabricated garments which can be laundered in domestic type washing machines, if removed before the final centrifuging (spinning), and followed by drip drying.

(*d*) Hand-wash, drip-dry—A term applied to a variety of fabrics or properly fabricated garments which can be washed by hand, removed without twisting, wringing or centrifuging, and followed by drip drying.

High-Temperature Test for Asbestos Textiles

The testing of asbestos textiles at elevated temperatures provides a significant method by means of which the quality and the elevated temperature serviceability of such materials may be evaluated. Since asbestos textiles are usually composed of blends of asbestos with cotton, temperatures above 300 F will promote the degradation of the cotton content and will reduce the structural reinforcement derived therefrom. In the higher grade asbestos textiles, wherein little or no cotton is used, and in which the longer asbestos fibers are necessary if a satisfactory yarn is to be produced, the degradation in strength resulting from heat-aging up to 1000 F is low. In the case of the lower grade asbestos textiles, however, wherein amounts from 15 to 25 per cent cotton are incorporated, asbestos fibers having shorter lengths may be utilized and under the relatively low-service temperatures to which such materials may be subjected neither the cotton nor the cloth properties are greatly affected. However, the strength-imparting influence of the cotton is reduced at elevated temperatures and the entwining properties of the shorter asbestos fibers are the primary source of tensile strength and other physical properties of the textile. In view of this, Committee D-13 on Textiles recommended as tentative an elevated temperature test to indicate the asbestos fiber grade or quality which may be used in a textile construction.

Another use and perhaps more practical application for the information to be derived from elevated temperature studies is the revelation of the ability of a subject textile to withstand known elevated temperature service conditions.

Tire Cord Methods Broadened

New methods for evaluating rayon, nylon, and polyester tire cords have been developed in recognition of the newer synthetics available for this purpose. The new methods will replace present methods for rayon tire cords (D 885).

A special feature of the textile committee meeting was the presentation of the Ninth Award of the Harold DeWitt Smith Memorial Medal to Stephen J. Kennedy, research director, Textile, Clothing, and Footwear Division, Quatermaster Research and Development Center, Natick. Mass. The dinner was sponsored jointly by Committee D-13 and the Washington District Council (see story on page 22).

Leather

New Look at Properties

Leather testing, for many years, has consisted principally of cutting specimens and testing to destruction. Such tests, of course, gave information on the failure properties of leather. When one considers the way in which leather is usually used it becomes apparent that the more important properties are those which do not involve failure of the leather. This point was discussed at some length in the research subcommittee of the ALCA-ASTM Joint Committee on Leather, at its meeting in New York on March 27–28. Nondestructive tests generally are being considered for evaluating leathers, including the use of ultrasonics in determining stress and strain characteristics. Also under investigation is the application of subdestructive stresses and examination of the early part of the stress-strain curve.

The measurement of properties of leather contributing to that elusive factor called "comfort" was also considered in the research group. It was felt that methods which correlate with subjective evaluation of comfort are needed, and there should be a long-term effort toward development of such tests.

The committee has completed two items to be included in its Annual Report this year—a method for corrosivity of leather and recommendations for conditioning of leather for testing.

Evaluation of deterioration of leather was attacked from several angles. About six different formulae for artificial perspiration are being studied. Other types of deterioration, such as cold cracking, light fastness, etc., are being investigated toward development of appropriate test methods.

Adhesives

Wood Assembly and Lamination Survey Presented

The chairman of the wood adhesives subcommittee of Committee D-14 on Adhesives presented a detailed survey of adhesive testing methods which have been used in assembly and lamination glueing at the meeting of the committee at the Forest Products Laboratory in Madison, Wis. on April 2 and 3. Research work in this field, particularly that of the Forest Products Laboratory and the Hardwood Plywood Institute, was described. In order to define the needed test methods, a detailed questionnaire was prepared to be circulated among manufacturers and fabricators of pulp and particle boards and laminated products. All manufacturers using wood adhesives were urged to report to the chairman, Mr. A. A. Marra, research engineer, School of Natural Resources, University of Michigan in Ann Arbor. The subcommittee expects to meet in Seattle, Wash., within the next few months in order to reach wood manufacturing operations in that area.

The Subcommittee on Metal Bonding Adhesives reviewed new and existing methods which may be included in its program The proposed program covers mechanical properties, durability, metal surface preparation, and inspection and quality control. The Forest Products Laboratory has, over the past few years, conducted research to develop methods for testing metal bonding adhesives; a presentation of this work was made by a member of their staff.

A new subcommittee is being formed to develop standards for adhesives for reinforced plastics.

Other test methods currently being studied by the committee include: aging tests for adhesives for acoustical tile, a method to determine the flow of adhesives under load, a determination of the tackiness of adhesives using the Hercules tack tester, and a method of determining the area and density of penetration of adhesives in a standard substrate.

Engine Antifreezes

Field Tester Spec Revised

Committee D-15 on Engine Antifreezes has approved a complete revision of the hydrometer-thermometer field tester (Specification D 1124) for presentation to the Society. This action at its meeting in Washington D.C. on March 27 will provide hydrometer manufacturers with a uniform method of calibrating antifreeze hydrometers up to and including a higher liquid density range. Formerly, the method permitted high-density liquids to be measured with the pycnometer, and since values utilizing this instrument were often quite different from calibrated high-density values, a revision of this method was necessary.

Study is continuing on interfering ions which give spurious values in the

determination of water in engine antifreezes using the Karl Fischer reagent. Difficulties in obtaining standard tubes for precise aeration rate in the glassware foaming test are causing delay in the completion of this work. The National Bureau of Standards direct freezing method which can be used as a routine control test is being reviewed for possible development as a standard method.

A full-scale pilot model of the reservoir assembly equivalent to an automobile engine block is now under test. At the completion of this study, patterns will be made for casting this reservoir on a production basis for use in an interlaboratory simulated service corrosion test program.

Your Committee Officers

A regular series—to better acquaint BULLETIN readers with the men whose responsibility it is to direct the indispensable work of the ASTM technical committees.

Committee B-1 on Wires for Electrical Conductors

Chairman—D. Halloran, Consolidated Edison Co.

Vice-Chairman—W. R. Hibbard, Consulting Chemist and Metallurgist

Secretary—A. A. Jones, Anaconda Wire & Cable Co.

Committee D-20 on Plastics

Chairman—F. W. Reinhart, National Bureau of Standards

First Vice-Chairman—A. C. Webber, E. I. du Pont de Nemours & Co., Inc.

Second Vice-Chairman—A. G. H. Dietz, Massachusetts Institute of Technology

General Secretary—J. B. DeCoste, Bell Telephone Laboratories, Inc.

Membership Secretary—R. H. Carey, Bakelite Co.

Meeting Secretary—B. L. Lewis, Tinius Olsen Testing Machine Co.

Paints

New Methods for Specifying Color

A new method of test for specifying color by the Munsell system, based on the color-perception attributes, hue, lightness, and saturation, was considered by Committee D-1 on Paints, Varnish, Lacquer, and Related Products at its three-day meeting in Louisville, Ky., early in March. The method is limited to opaque objects, such as painted products, viewed in daylight by an observer having normal color vision. This method provides a simple alternative to the more precise and more complex method of color specification based on spectrophotometry and the CIE system as described in Methods D 307. Provision is made in the method for conversion of CIE data to Munsell notation when desired.

A new method of test for color differences using the "Colormaster" differential colorimeter was recommended as tentative. Work is being undertaken on instrumental color methods for determining tinting strength of white pigments. Plans were made to have on view at the next meeting of the committee in June, various color matching and lighting equipment. The group is studying primary and secondary sources of lighting. A series of panels showing sample color differences will be prepared for use in this project.

A new Subcommittee on Statistical Applications was organized. This subcommittee proceeded immediately with the appointment of two groups—one on experimental design of cooperative tests and the other on interpretation and presentation of cooperative test data.

The committee joined with the Louisville Paint and Varnish Production Club in sponsoring a dinner meeting on March 6. J. S. Long, professor, University of Louisville, and director of the Paint Research Inst., Inc., gave a talk on Research in Protective Coatings. (See "Shrinking Portion of Consumer Dollar Spent on Paint Industry," ASTM BULLETIN, April 1958, p. 46.)

At a luncheon on Friday, March 7, the committee presented scrolls to the following seven honorary members: J. F. Broeker, M. B. Chittick, E. F. Hickson, F. H. Lang, G. G. Sward, M. Rea Paul, and R. D. Bonney. This was the first luncheon to pay tribute to those on which this honor had been conferred by the committee.

New definitions for caulking and glazing compounds developed by committee will be published as tentative. The committee has decided that ASTM methods for testing putty, glazing, and

caulking compounds should include procedures for extrudability, dirt collection, paintability, slump or flow, staining, color retention, waterproofness, and storage stability. Studies are under way on accelerated testing which will cover adhesion, bond, ductility, shrinkage, hardening, and flexibility.

The Subcommittee on Varnish recommended a new tentative method of test for color of transparent liquids. Also submitted as tentative was a new viscosity test by the bubble time method which is an alternate to the present Method A in Methods D 154. Test methods for polyurethane coatings are being developed. The unusual properties of this class of coating appear to require a special review of test methods for applicability. Other test methods for varnishes being studied include skinning tests, rosin content, phenolic content, color of dried transparent films, and phthalic anhydride analysis.

The Subcommittee on Drying Oils has established a group to develop a qualitative test for fish oil. Specifications are being prepared for boiled and double-boiled linseed oil which eventually will replace the present standard specifications.

The Subcommittee on Accelerated Tests for Protective Coatings has been giving attention to evaluating the blister resistance of house paints. Plans were discussed for undertaking the preparation of a set of standards for evaluation of very fine blistering too small for representation by ordinary photography. Three-dimensional plastic replicas and stereoscopic colored transparencies will be considered. Work is being undertaken on the preparation of concrete and masonry panels for weathering tests. The committee has completed a new tentative test for resistance of white architectural enamels to color change. A proposed method of test for perspiration resistance of organic coatings is under study. Several cooperators have agreed to test several coatings by this method. It is hoped to have some preliminary results available by the June Meeting. A new method for resistance to staining of transportation finishes has been approved by committee vote and will shortly be issued as tentative. The committee is investigating a thermal shock test for organic finishes on metal. A method for evaluating panels after exposure to corrosive atmospheres is being developed. The committee will extend the scope of four existing weathering test methods for paint so that the weather effects on other types of coatings than linseed oil paints can be included. These methods cover checking (D 660), cracking (D 661), erosion (D 662), and flaking or scaling (D 772).

The Subcommittee on Solvents was reorganized and its scope enlarged to include the lacquer solvents formerly under the jurisdiction of another subcommittee. All the solvent specifications were given a thorough review this year.

Several round-robin test studies are under way on latex and emulsion paints. This includes studies of test procedures for such characteristics as workability, efflorescence, freezing and thawing resistance, package stability, coalescence, and weathering characteristics.

Appearance

Coming—A Manual on Appearance Evaluation

How do materials look to vice-presidents, to project engineers, to technicians? No doubt the point of view makes a difference and on this point Committee E-12 on Appearance agrees, for the three parts of its Manual on Appearance Evaluation of Materials, now in preparation, are: I. appearance evaluation for vice-presidents, II. ...for project engineers, and III. ... for technicians.

The nine chapters will cover classification of appearance attributes, evaluation by visual and instrumental means, scales and tolerances for appearance, measurement and control techniques and published methods for appearance measurement. Also to be included are terms and definitions and bibliography.

Do not look for the Manual tomorrow or next month—it is yet to be written, but the assignments for preparation of various chapters were made at a meeting of the committee in Washington, D. C. on March 25.

Other activities of the committee included a report of the Subcommittee on Color that the round-robin test program on study of a method for determining color of petroleum, coal-tar, and related resins was continuing. It is hoped that these tests will be completed shortly so that the results can be presented to the committee at its next meeting in June.

The Subcommittee on Gloss has been cooperating with other technical committees of the Society in the development of gloss methods, methods for goniophotometry, and visual classification procedures.

The committee held a joint panel discussion with the Inter-Society Color Council on the subject "Measurement and Specification of Color in Building Materials." The moderator at this panel discussion was Stanton Petry, assistant secretary of Committee E-12, W. M. Welch Manufacturing Co., Chicago, Ill. The panel discussion covered the following subjects:

"Porcelain Enamel," by Bob Pattrick, Porcelain Enamel Co., Baltimore, Md.

"Ornamental Finishes," by M. D. P. Jenny, Portland Cement Association, Chicago.

"Aluminum Panels," by R. V. Paulson, Kaiser Aluminum and Chemical Co., Spokane, Wash.

"Paints and Varnishes," by Sam Huey, Sherwin Williams Co., Cleveland, Ohio.

"Visual Methods," by Norman Pugh, Sears Roebuck and Co., Chicago, Ill.

Each of the panel members presented a short talk describing methods, standards, advantages, weaknesses, and special problems of measurement and specification of color and other color attributes in his particular material industry. At the conclusion of the five talks there was a very interesting discussion which indicated a very real and wide interest in this subject.

ASTM STANDARDS AT WORK

Gas Shipment Speeded by Use of Spec A 352

Ethylene gas is now being shipped through an underground pipeline, 20 miles in length, between an Esso refinery in Linden, N.J., and a Hercules Powder Co. polyethylene plant.

Throughout most of the trip, the gas is moved under pressures of 600 psi. For metering and regulating purposes the pressure is drastically reduced causing the temperature of the gas to drop to 150 F below zero.

The meter station is equipped with valves cast of nickel alloy steel which conform to ASTM Standards A 352. The normalized-and-tempered nickel steel casting meets an impact strength of 15 ft-lb (Charpy keyhole) at this low temperature.

This is another example of the continuing use in industry of ASTM Standards.

Soaps

Latest Analytical Methods Used

Many of the latest analytical techniques are being uti ized by Committee D-12 on Soaps and Other Detergents in its attack on the many problems encountered in the development o' specifications in this complex field. At its recent meeting, it was noted that methods being developed or under consideration as specifications included the determination of active ingredients by ultraviolet absorption spectroscopy and cationic titration, the rapid determination of moisture by means of an infrared lamp, and the identification of sodium triphosphate by paper and ion-exchange chromatography. In addition, a project was initiated to investigate the analysis of sodium triphosphate by reverse flow ion-exchange chromatography.

A new subcommittee appointed to investigate methods of analys's for synthetic detergents presages an even greater diversity of attack in the future.

The evaluation of detergents in dishwashing is also under consideration by the committee. A survey revealed that five areas of testing are involved—detergency, corrosion on metals, chemical attack and staining of dishes, foaming, and shelf life.

As part of the Committee's study of primary soil deposition, an annotated bibliography on soiling is being compiled and should be completed within the years.

These actions were reported at a meeting of the committee at the Park Sheraton Hotel, New York City, on Tuesday, March 11, J. C. Harris presiding.

Emission Spectroscopy

Planned for '59—A Symposium on Spectroscopic Light Sources

A symposium on spectroscopic light sources 's being planned for the 1959 Annual Meeting by Committee E-2 on Emission Spectroscopy. This symposium, announced at a recent meeting, is another step in a series covering investigations of the fundamentals of emission spectroscopy.

Bibliographies are being assembled on flame photometry and X-ray fluorescence. Other tasks in progress include the compilation of unsolved problems in spectrochemical analysis, the maintenance of a current list of standards and pure materials available throughout the world, the compilation of a summary of the characteristics of various photographic film emulsions, and the preparation of a report comparing the specifications of the various modern spectrographs available in the United States and Canada.

The committee met on March 6, 1958 at Pittsburgh, Pa. during the Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy.

Absorption Spectroscopy

Magnetic Resonance Subcommittee to Be Formed

A task group on magnetic resonance spectroscopy is being formed by Committee E-13 on Absorption Spectroscopy in view of the recent high level of activity in this field.

The rapid expansion of spectrophotometry in both applications and types of apparatus has led the committee to recommend the revision of their scope to the following form:

> The advancement of the fields of spectroscopy involving molecular, atomic, or nuclear absorption, and fluorescence, scattering, or polarization, by promoting exchange of information, by sponsoring meetings and symposia for presentation of papers, and by coordinating and formulating scientific practices and methods of analysis in these fields.

Symposium Planned on Fluorescence Spectroscopy

Plans were also made to sponsor a symposium on fluorescence spectroscopy in conjunction with the meeting of the Society for Applied Spectroscopy, November 6 and 7, 1958, in New York City.

Other activ'ties of the committee include the establishment of a subcommittee on fluorescence spectroscopy to organize activity in this resurgent field, planning for the compilation of a formula-name index for the ultraviolet spectral punched cards, and planning for the preparation of cards for indexing spectral data in the near-infrared range (the range of spectrum between the visible and the conventional infrared).

The committee met on March 3, 1958, at Pittsburgh, Pa., during the Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy.

Papers to Appear in Future Issues of the ASTM Bulletin

The Low Temperature Brittleness Testing of Polyethylene: A New Apparatus and Subsidiary Equipment—P. N. Bestelink and S. Turner, Imperial Chemical Industries, Ltd.

Creating Test Atmospheres at −260 F—John Brown and G. V. Thompson, The Martin Co.

Tests for and Engineering Properties of Ceramic Tile—J. V. Fitzgerald and E. L. Kastenbein, Rutgers University.

The Elastometer—A Simple Device for Measurement of Elastic Moduli at Elevated Temperatures—R. A. Spurr, Hughes Aircraft Co., M. J. Heldman, formerly of Hughes Aircraft Co. now with East Los Angeles Junior College, and Howard Myers, formerly of Hughes Aircraft Co., now with Douglas Aircraft.

Behavior of Certain Alloys Subjected to Dynamic Loading—R. G. Crum, Carnegie Institute of Technology and F. T. Mavis, University of Maryland.

Determination of the Apparent Density of Hydraulic Cement in Water Using a Vacuum Pycnometer—C. L. Ford, Portland Cement Assn.

Corrosion of Concrete by Sulfuric Acid—W. C. Hansen, R. P. Vellines, and W. W. Brandvold, Universal Atlas Cement Co.

Hydraulic Cement for Water Tanks and Pipe Lines—W. C. Hansen, Universal Atlas Cement Co.

Changes in Mercury Thermometer Calibration Correction Values at −30 C—W. I. Martin, S. S. Grossman, and J. J. McGovern, Koppers Co.

A Comparison of Cement Strengths in Mortars and Concretes—M. A. Swayze, Lone Star Cement Corp.

Papers Invited for Fifth Nuclear Congress

Authors interested in presenting papers on engineering materials to be sponsored by ASTM at the 5th Nuclear Congress, April 5–10, 1959, are requested to submit the title and abstract of their proposed papers not later than July 15, 1958. (For details, see ASTM Bulletin, April 1958, p. 58.)

Offers should be addressed to C. R. Sutton, ASTM representative, Nuclear Congress, c/o International Nickel Co., Inc., 67 Wall Street, New York 5, N. Y.

Materials Standardization in Argentina

Editor's Note—This article was translated from the Spanish version prepared by Señora Beatriz Ghirelli de Ciaburri, executive director of IRAM, the Argentine Institution for Standardization of Materials. ASTM Executive Secretary Painter suggested that this article be prepared for the Bulletin during his visit to South America in September, 1957.

ORGANIZATION OF IRAM

THE first steps toward the establishment of a standardization organization in the Republic of Argentina were taken in the year 1935. Based upon an analysis of various systems in use in other countries, their organization, means of financing, etc., but taking into consideration conditions peculiar to this country, the task of approaching those groups which might sponsor the establishment and subsequent development of the "Instituto Argentino de Rationalización de Materiales (IRAM)" was begun.

Among these groups were the State Railway, the Ministries of War and Navy and Public Works of the National Government; and in private life, the Argentine Engineering Center, The Argentine Chemical Assn., the Argentine Industrial Union, as well as various sections of the latter, and other groups of foreign exporters, etc. Some industries were part of the Institute from the beginning, principally in the fields of metallurgy and electricity since their experience had already demonstrated the advantages of these studies.

Aims of IRAM

Such were the entities which met on May 2, 1935 and approved the founding Statute which stated the aims of the Institute to be:

To classify, unify, and standardize materials.

To establish the definitions, nomenclature, test methods, technical requirements, specifications and other standard requirements for materials and their applications, as well as to encourage study and knowledge of them.

To disseminate information.

To form collections of samples.

To prepare statistics.

To aid in the improvement and coordination of existing laboratories and in the creation of new ones for study and investigation.

To cooperate and aid in the organization of public expositions.

To organize and sponsor or participate in national and foreign congresses.

To coordinate and solicit contributions of public, group, and individual efforts.

To maintain relations with similar societies, to affiliate with those of international character, and to develop other activities leading to the standardization of materials and their applications.

Rapport was established with European societies by direct contact with France, Austria, and Germany. The British colony, for its part, linked the new organization with the British Standards Institution through the British railways in Argentina.

Relations with the societies in the United States were not so simple, since, at that time, there were no American firms in Argentina with an immediate interest in the subjects under initial consideration: metallurgy, electro-technology, and paints. This collaboration was obtained later by the mediation of Cyrus T. Brady, Jr., engineer, who represented the United States Steel Products, Co. in Argentina, and C. C. Batchelder, engineer, president of the General Electric Co. of Argentina and president of the North American Chamber of Commerce.

These two persons attempted to secure the fullest possible cooperation in the work by the standardization societies of the United States, establishing a permanent contact with the American Standards Assn., ASTM, and Underwriters' Laboratories.

Having taken the first step by obtaining standards giving the requirements in foreign countries for a given material, the Argentine situation was studied to determine which problems were most urgent of solution. It was decided to start with a study of the materials and products directly involved in the purchases of the governmental departments since it was they who were engaged in most of the public works: roads, sanitary systems, oil wells, construction, etc.

Once it was determined which subjects might be of interest, work plans sponsored by the founding members were drawn up, making possible the solicitation of members.

STAFF

When it was felt that the Institute was established on a sound financial basis, both a technical and an administrative staff were set up.

In view of the limited resources of the Institute the technical section was started with two, recently graduated, electromechanical engineers who assumed direction of the committees then functioning: metallurgy, metal pipes, construction materials, electrical engineering, and paints.

Foreign Sources Used

The routine technical responsibility of IRAM is to study national and foreign source material on a given subject and, in accord with these criteria, to prepare a standard outline which is then submitted for consideration to a study group drawn from industrialists, consumers, business men, and representatives of technical associations, such as research organizations, professional associations like the Argentine Engineers Center, etc., who have shown interest in the subject. Each of these represen-

tatives is authorized by his group to express an opinion on the projected standard.

In this way, then, although knowledge of the industrial process or of the requirements of the consumer may not be complete at the time the standard outline is prepared, study by specialists with diverse interests permits adequate coverage of the problem and also, in general, assures that all opinions have been respected in the establishment of the standards.

Naturally as IRAM has acquired a greater financial stability and as its members have become more familiar with the process of standardization, and have taken a more active part in the studies, and as a greater number of groups have become interested, it has been necessary in some cases to verify the results of foreign sources by its own tests; but this procedure has not yet become general and will become necessary only when study is started of the *natural resources*, which creates far more of a problem.

ADMINISTRATION AND FACILITIES

IRAM is administered by a Board of Directors, an honorary body, elected at the annual meetings by vote of all members with voting privileges.

The administrative department is, properly speaking, divided into two sections:

(*a*) The financial section handling matters dealing with the admission of members, sales of standards, purchases, etc., is directed by an administrative manager.

(*b*) The Secretariat is responsible for the membership file, the file of members of study groups, the progress of the study and elaboration of standards, etc., correspondance, and files. It is in charge of mechanical transcription of the work of the technical section and its progress, citations, etc.

There are, further, two complementary sections: one, the Library, an adjunct of the Technical Section; and the other, Publicity and Public Relations. The Library provides a valuable service to the members in addition to being indispensable to the work of the Technical Section since it contains the publications of standardization societies throughout the world. This Library is open to the public.

The Publicity and Public Relations Section handles, under the supervision of the General Management, the publication of the journal, "Informaciones IRAM," the Catalog of Standards, and relations with governmental and private entities, as well as the promotion of new members.

The sources of revenue of the Institute are, for the most part, the dues of the members. However, in 1956 a novel source was opened consisting of inspections to determine whether a material meets the established safety standards.

In considering the economic evolution of the Institute, one must keep particularly in mind the process of inflation which the country has experienced recently, making it impossible to consider the annual budgets separately. A more accurate index would be the number of groups engaged in the work year by year as given in the reports of 1954 and 1955 covering the period of stabilization after the grave crisis of 1950.

At present the Institute staff comprises a stable corps of 45 persons distributed as follows:

GENERAL MANAGER

Technical Director

Technical Department	2 engineers, 2 doctors of chemistry, 1 surveyor, 8 technicians, 2 draftsmen
Accounting Department	7
Secretariat	14
Publicity	1
Library	2
Service Personnel	4

The standards approved and under study at the end of 1957 include the following subjects:

Fundamentals	Railway Material
General Tests	Textiles
Metallurgy	Agricultural Machinery
Applied Chemistry	Hides
Construction Materials	Weights and Measures
Electro-technology	Wood
Metal Pipes	Soils
Papers, Inks, and Related Products	Automobiles
Fire Protection	Pesticides
Telecommunications	Buildings
Drafting	Refractories
Applied Mechanics	Milk Products
Oils, Greases, and Derivatives	Alcoholic Beverages
Containers	Fertilizers
Petroleum and Derivatives	Glass
	Metals and Precious Stones
	Mineralogy
	Photography

NATIONAL COMMISSION FOR STANDARDIZATION OF MATERIALS

When the work of establishing the Institute was started, it was a primary concern that the standards to be approved by the organization should be immediately accepted by governmental departments.

For this purpose, in 1938, various steps were taken. One of the principal promoters was Vice Admiral don Francisco I. Stewart who at that time was director of the General Administration for Naval Material, and who has been for many years, without interruption, president of IRAM.

As a result of this effort toward affiliation, there was obtained the promulgation by the Executive Branch of the Government, with the approval of all the ministries, of a Decree creating the National Commission for Standardization of Materials whose principal functions are:

(*a*) To promote nationally the study and standardization of materials.

(*b*) To give official sanction to the standards.

(*c*) To elaborate plans for the creation of a central laboratory, a specialized library, and other necessary elements which may be indispensable for the discharge of its function.

In regard to the Institute, this Decree states:

> The National Commission for Standardization of Materials will make use of the Argentine Institute for Standardization of Materials as the unifying organization for the technical-scientific study of standards in order to maintain uniformity of systems and criteria in their constitution.
> All other existing entities or those which may be created for the study of standards will submit their results to the National Commission for Standardization of Materials so that it may, after study and advice of IRAM, proceed to their promulgation, if deemed convenient.

To understand the need for official approval of the standards, it must be recalled that at the time of creation of the Institute the principal purchaser of standards would be the National Government, which had at that time, and does not have now, a standardization department.

The action of the National Commission for Standardization of Materials, which consists of representatives from various ministries, a representative from industry and from the Institute, has been very important since the requirement that the various State pur-

chasing departments buy supplies meeting IRAM standards has accustomed the manufacturer to work with them, arousing his interest gradually so that today the orders received from the Government and from the industrial group are completely in balance. Recently a very active participation in the commercial sector has been noted.

In spite of that action by the National Commission, industry complained of the difficulties in supplying materials because of the enormous disparity in the criteria of the various State purchasing departments. Iram then took steps to have the official IRAM standards made obligatory for State purchases by the national administration. The approval of this Decree was obtained last August.

Hence, and possibly in a very short time, Argentine industry will improve the quality of its production, since at present it is interested in having IRAM verify whether its products meet the respective standards.

SEAL OF QUALITY

The Institute considers it is now time to establish the service of the *Seal of Quality*, or conformity with standards, which is, in its judgment, the only practical realization of a standard.

The idea has been presented many times, but, in fact, the importance given to the work of IRAM by industry was not sufficient to be able to carry out this wish.

Continued work, activity in various surveys, and the necessity of Argentine industry to certify the quality of its products in order to meet competition nationally and to win the confidence of foreign export markets, have permitted the adoption of these proposals; and in 1958 there will be domestic electrical appliances bearing the *IRAM Seal of Quality* as well as fire extinguishers and steel cylinders for gas.

IRAM has no experience in this aspect of the work but it demonstrates the direction national economics are giving to standardization work.

Penn State Offers Short Summer Course in Materials

Materials Engineering Design for High Temperature.—This course will be held June 29 to July 3, 1958 on the Penn State Campus and will include metallurgical properties, mechanical static properties at high temperatures, thermal shock, and fatigue properties, and design for high temperatures. Lectures will be given by a number of prominent engineers and scientists in the field.

District Activities

CLEVELAND

Composite Materials Offer Advantages for Space Vehicles

The challenges to materials presented by the arrival of the astronautics era highlighted a recent meeting of the Cleveland District. Colonel R. A. Jones, USAF, a staff officer for materials in the Research and Development Command, reviewed the critical material problems posed by the existing and anticipated performances of space vehicles. Col. Jones discussed some of the unexpected results of current research in this field, particularly in the utilization of composites which can utilize advantageous properties of metals, ceramics, and organic polymers.

Col. Jones reviewed various aspects of the environmental and operational requirements facing the materials which must be used in the future by the Air Force. He contrasted the current emphasis on military capabilities in being ready for instant use, as against the stock piling of machinery and raw materials which could only be utilized over an extended period of time. This new approach to readiness has posed a new urgency in materials research.

Following the talk, the wide range of industrial interests present drew forth a discussion of the Air Force's approach to metals, plastics, and the ceramic materials which are not in commercial production by industry.

L. F. Herron, chairman of the Cleveland District, presided.

DETROIT

Molybdenum and Missiles

Missile-Structure Testing was the coffee talk topic by Donald E. Dresselhouse, manager of engineering of the Structural Laboratory Department, Chrysler Missile Division, at a recent meeting of the ASTM Detroit District. Mr. Dresselhouse showed slides to illustrate methods and procedures of qualifying missiles by evaluated temperature and production static testing of the structure and the foil skin.

The Detroit District was the third ASTM group to hear Alvin J. Herzig, president, Climax Molybdenum Company of Michigan, give his popular 1958 Gillett Memorial Lecture on Molybdenum.

19 Student Awards Given

The Detroit District also made student awards to the following 19 students from Detroit and Michigan colleges and universities. Wayne State University: Gerald Paul Lang, Jay Francis Snell, Charles Olmstead (second year), David Petrillo (second year), Robert David Leland; Michigan State University: Douglas Duquette, John C. Bierlein, Leonard W. Bell, Thomas Bloodgood, and Dean Cooper; University of Detroit: William P. Hart, Edwin H. Hetrick, Donald J. Malaker (second year), Michael F. DeMalonbus (second year); University of Michigan: Robert Scott, Richard H. Cullen, Glen C. Smith (second year), James A. Ford, Henry Branch (second year).

At the conclusion of the meeting, John M. Campbell, Scientific Director, Research Laboratories Division, General Motors Corp., was made a District honorary member and presented with a certificate. In his acceptance remarks Mr. Campbell took the opportunity of speaking to the students who had received awards, pointing out to them the importance which may be attached to activities in professional and technical societies outside of the man's working hours, that these activities contribute greatly to the broadening of his knowledge and his insight into his profession.

WASHINGTON D. C.

Textile Committee Honors Kennedy

Committee D-13 on Textiles presented the DeWitt Smith medal to Stephen Kennedy, research director, Textile, Clothing, and Footwear Division, Quartermaster Research and Development Center at a joint meeting of the committee with the Washington District.

Opening remarks were given by B. L. Whittier, School of Textiles, North Carolina State College, the chairman of Committee D-13. Richard T. Kropf, president of ASTM, acted as Toastmaster for the dinner meeting. Milton Harris, vice-president of the Gillette Co., made the presentation speech in which he outlined Dr. Kennedy's service to the nation and to the science and technology of the textile industry.

In his response Dr. Kennedy reviewed the work done by the Quartermaster Corps in materials research, particularly stressing the textile and clothing field.

Dr. Kennedy has had a distinguished career in the service of the U.S. Army Quartermaster Corps during World War II and subsequent thereto. A graduate with a degree of B.A. in 1926 from the University of Illinois, he received the degree of M.A. from Columbia University in 1931, and Ph.D. in 1936. During the period 1935–1941 he was director of market research for Pacific Mills. Dr. Kennedy's service with the Quartermaster Corps began in 1942, when as Lt. Colonel, U.S. Army, he became chief, Textile Section, Research and Development Branch, Military Planning Division, O.Q.M.G. For his wartime accomplishments he was cited for the Legion of Merit.

The Smith Medal is a testimonial to the memory of the late Harold DeWitt Smith who pioneered in the concept of an engineering approach to the evaluation of the properties of textile fibers and to their utilization. The medal award was established by the Fabric Research Laboratories, W. G. Hamburger, director.

CHICAGO

The Chicago District Council took advantage of an opportunity presented at the Nuclear Congress to hold a luncheon meeting on March 19 at the Stock Yard Inn. ASTM President Richard T. Kropf spoke, outlining the needs and resources of technical manpower of America as it moves along "The Road to the Future."

Included in the audience of about 100 were overseas visitors from Belgium, Israel, Germany, and France, who were attending the Nuclear Congress.

New Southeastern District Officers

The officers of the newly formed Southeastern District Council represent a broad sector of the industrial South. They are: J. A. Lee, Southern Brick and Tile Manufacturers Assn., chairman; R. W. Mooty, Tennessee Coal and Iron Division, U.S. Steel Corp.; vice-chairman; C. J. McMurry, Rome Cable Corp., secretary; and R. E. Deas, American Cast Iron Pipe Co., assistant secretary.

J. A. Lee, chairman

R. W. Mooty, vice-chairman

C. J. McMurry secretary

R. E. Deas, assistant secretary

1957 Proceedings

The 1957 ASTM *Proceedings* has gone to press, and members who have requested copies should have them sometime before the Annual Meeting. The 1440-page volume, recording the technical accomplishments of the year, includes reports and papers together with discussion offered to the Society during the year and accepted for the *Proceedings*. The volume includes the Summary of Proceedings of the 60th Annual Meeting and the Summary of Proceedings of the Philadelphia Spring Meeting, listing by title and author the programs for each session.

The annual President's address by R. A. Schatzel, "Our Expanding Technology and ASTM," emphasizes the Society's responsibilities in areas for contributions to the national technical welfare. Dr. Schatzel stresses the need for better communication, discusses the Society's cooperative efforts with Government agencies and other societies, and discusses briefly the job ahead and plans for the future.

The annual report of the Board of Directors highlights matters administrative, technical, and financial for the benefit of members. Included are records of all meetings held by the Society and its districts, information on membership gains, publications, honors, and awards, and other matters of interest. There are 66 reports of technical committees which, together with appendices, provide a wealth of useful information as do the 52 technical papers and discussions on a wide variety of subjects pertaining to research and testing materials.

In addition to the papers and reports embodied in the *Proceedings*, there are listed all symposia and other special sessions published separately as *Special Technical Publications*, and all papers published in the ASTM BULLETIN.

Although the Society's publications program has expanded greatly in recent years with an ever increasing number of *Special Technical Publications*, the *Proceedings* remains the repository of factual information and a record of the Society's work. An important adjunct is a subject and author index to all papers published in any form by the Society in 1957.

It should be emphasized that in addition to the reports and technical papers, many of which have been given at the national meetings and some of which have been preprinted, the *Proceedings* contains much discussion not previously published.

ASTM and the Refining Industry—

By HAROLD W. FERGUSON

ASTM's role in the expanding petroleum industry—more standards for petrochemicals and other petroleum products

Mr. Ferguson, API vice president for refining and vice president of the Humble Oil Co., in this address presented before a joint meeting of the ASTM Southwest District and Committee D-2 on Petroleum Products and Lubricants on February 3, in Houston, Tex., describes many of the accomplishments and some future problems of ASTM and the refining industry. With the increasing use of petroleum as a source of industrial chemicals, there are corresponding needs for standards. Some of this work—for example, standards for olefins—is being done in Committee D-2. Other petroleum-derived chemicals are being standardized in various of the Society's committees—the aromatics in Committee D-16, paint solvents in Committee D-1, antifreeze in Committee D-15, and halogenated solvents in the new Committee D-26, to name a few. Over-all cognizance of chemicals standards in the Society is a responsibility of the Advisory Committee on Industrial Chemicals established in 1957 to advise the ASTM Directors on an orderly expansion of work in the chemicals field.—*Editor*

NEARLY everyone present is probably familiar in a general way with the activities of the American Petroleum Inst. and the American Society for Testing Materials. However, there may not be complete understanding as to the exact functions of these two organizations, and it might be well to spend a few minutes distinguishing between the activities of the two.

Objectives of API

The American Petroleum Inst. is an association of some 7000 oil men and is the oil man's forum, information bureau, technical clearing house, and national trade association. Its objectives, as stated in its charter, are: to afford a means of cooperation with the Government in all matters of national concern, to foster foreign and domestic trade in American petroleum products, to promote, in general, the interest of the petroleum industry in all its branches, and to promote the mutual improvement of its members and the study of the arts and sciences connected with the petroleum industry.

These objectives are accomplished through the divisions and research committees of the Institute. It has divisions on production, marketing, transportation, and refining. The Refining Division has two committees of particular interest: the Committee on Analytical Research with subcommittees on oxygenated compounds, emission spectroscopy, waste disposal analysis, nitrogen, sulfur, sulfur types, and X-ray diffraction, and the Committee on Petroleum Products which deals with matters which relate to uniform methods of testing and sponsors research in the field of testing. Under its direction, standards, such as oils for the calibration of viscometers, are produced.

The work of the research committees of API is well known. Projects sponsored by the Committee on Fundamental Research on Composition and Properties of Petroleum and the Committee on Fundamental Research on Occurrence and Recovery of Petroleum have produced authoritative information and standards which are recognized by all who have anything to do with the industry. The physical and spectral data published by API Project 44 are perhaps the best known products of API research.

Interrelation of ASTM and API

API carries on standardization activities relating to petroleum products only in noncontractual fields, such as methods of analysis applicable to waste disposal problems, for example. When methods are developed which could be contractual, they are turned over to ASTM for standardization. For instance, the method for determination of purity by the freezing point procedure was developed as an API project, but was reviewed and established as a standard by ASTM.

The Institute works very closely with ASTM in furnishing services to the petroleum industry. As a matter of fact, it furnished the Secretariat of ASTM Committee D-2. The information from many of its research projects is used by ASTM in the standardization of procedures. The determination of viscosity at high rate of shear, the calculations for the petroleum measurement tables, the determination of octane number at high altitudes, and the production of the viscosity conversion and viscosity index tables are but a few of the projects in which API has given assistance.

While API furnishes services primarily for the petroleum industry, ASTM works for all industries including petroleum. The two organizations frequently work together in areas relating to petroleum and in the development of knowledge of materials of engineering. The standardization of specifications and methods of test is exclusively an ASTM activity. It has the distinction of including consumers and general interest members, as well as producers, in making its decisions. All industries participate in its deliberations, since the conclusions reached have a very significant bearing on economy of operations. For example, we in the petroleum industry are consumers of steel and are interested in steel specifications.

ASTM Serves the Petroleum Industry

ASTM has made many valuable contributions to the petroleum industry. When I first became interested in testing, most laboratories kept their test methods secret. Now, however, the procedures are well standardized and are published so that the consumer is able to determine for himself whether products meet specifications or not. Using data from many sources, ASTM has combined and helped standardize the petroleum measurement tables so that they are now being considered for adoption on a world-wide basis. Committee D-2 can look with pride on the fact that in 1955 the Federal Standard methods for testing petroleum products referred to 156 ASTM procedures by number only. This means that these methods were approved as special Government procedures so that it is no longer necessary to set up special apparatus and methods in order to use them. I am glad to learn that Committee D-2 is continuing its efforts to have more of its methods accepted by government agencies.

Although ASTM has always striven for accuracy and precision, it is gratifying to see that the methods for testing petroleum products continue to be improved in this respect. I am also pleased to see statistical methods being used more extensively to pinpoint the need for more accurate methods in important tests such as octane rating and sulfur determination. Not only are the methods becoming more precise, but steps have been taken to make them faster. It used to take about eight hours to determine the sulfur content of oils by the bomb method. Now this element can be determined with equal accuracy on most of the same stocks in about 20 min by the high-temperature combustion method. This difference in time becomes exceedingly important if it means holding a ship in port.

Future of the Refining Industry

Having reviewed briefly the organization and accomplishments of API and ASTM, I believe it would be worth while now to consider where we are going in the petroleum refining industry. By so doing it should be possible to pinpoint those areas where ASTM may expect to find an increasing need for standardized methods.

The trends in motor-gasoline octane rating will continue upward for some time to come. To meet the higher requirements, the gasoline of the future will have to be "tailor-made" by the proper blending of high-octane components. We can expect to see a marked increase in the volume of catalytic reforming capacity to produce aromatics, and in alkylation and isomerization capacity to produce the necessary high-motor-octane paraffins. There will also be a continuation of the upswing in hydrogen treating of gasoline components to reduce the sulfur level below 0.01 per cent. This is necessary, of course, to take fullest advantage of tetraethyl lead.

The demand for aviation grade gasolines has just about hit its peak and will begin to decline in 1960. It is reported that the military has purchased its last piston-engined plane and that the major commercial airlines will receive their last ones next year. The expected decrease in future aviation gasoline requirements dovetails with the increasing motor gasoline octane needs, but it is obvious that the cost of motor gasoline will tend to rise as the supercomponents are transferred from aviation to motor gasoline.

The switch to jet airliners will bring about a remarkable increase in the demand for jet fuels. It is expected that there will be over 300 jet airliners in operation on U. S. lines by the middle of 1961. Commercial requirements in 1956 were less than 10,000 barrels per day. Total jet fuel requirements are expected to reach 800,000 barrels per day by 1965.

Petrochemicals Still Growing

By far the most spectacular change taking place in the petroleum refining industry today, however, is the rapid growth in the number and volume of petrochemicals. Aside from certain alcohols and additives, the first large-scale entries were introduced during World War II: toluene, butadiene, and butyl rubber. The list has grown till in 1956 petrochemicals accounted for 25 per cent of the total chemicals business volume-wise. This expansion is expected to continue with petrochemicals constituting over 40 per cent of the volume total and nearly 70 per cent of the dollar total by 1965.

Throughout this period of growth the great bulk of the petrochemicals recoverable by simple separation techniques, such as distillation and crystallization, are produced either in catalytic cracking or reforming processes. The light gases from the catalytic cracking units are rich in ethylene, propylene, butylenes, and other olefins. Ethylene is recovered by superfractionation for subsequent conversion to a host of useful chemicals, including polyethylene, ethyl alcohol, ethylene oxide, ethylene glycol, and styrene.

Propylene can be polymerized in the raw propane stream to yield propylene polymer for inclusion in motor gasoline. An attractive alternate disposition of the polymer is to recover the trimer and tetramer fractions for further processing; the trimer is used to produce C_{10} alcohols by the oxo process and the tetramer is reacted with benzene to produce a raw material for detergent manufacture. Alternatively, the propylene can be purified by distillation for subsequent conversion to polypropylene, isopropyl alcohol, acetone, or to isopropylbenzene for subsequent production of phenol and acetone.

The major petrochemical uses of the butylene fraction in the foreseeable future will continue to be for the production of butadiene and butyl rubber.

More Aromatics Too

The aromatic hydrocarbons currently being recovered from catalytically reformed petroleum fractions include benzene, toluene, paraxylene, orthoxylene, and ethylbenzene, as well as a number of mixed aromatic concentrates. It is likely that metaxylene, pseudocumene, and durene will join the list of pure aromatics in the not too distant future. Most of the polymethyl benzenes are oxidized to acids before subsequent use, and it is highly probable that many of these acids will become common articles of commerce in the

near future: terephthalic acid from paraxylene, isophthalic acid from metaxylene, and pyromellitic acid from durene, to name a few.

These remarks are not intended to represent a comprehensive survey of the future of the petroleum refining industry. They simply call attention to the trends and the high points, but perhaps will be adequate to serve as a guide in our thinking of the future analytical requirements of the industry.

Analytical and Testing Problems—Need for More Precise Octane Ratings

With the foregoing trends in mind, let us consider a few of the analytical and testing problems confronting the petroleum refining industry. One of these which ranks high in both refiner and consumer interest is the matter of motor fuel octane number measurement.

The development and maintenance of rapid and inexpensive tests which accurately predict fuel performance is a responsibility of ASTM Research Division I. The predicted performance of automotive fuels is normally expressed in terms of an arbitrary scale of octane numbers; this scale, in turn, is based on the knocking characteristics of two pure hydrocarbons—isooctane and *n*-heptane—under prescribed test conditions. The octane number of a motor fuel is derived by relating its knocking characteristics to that of a blend of the two reference hydrocarbons. Correlation data relating octane numbers to full-scale engine performance have been established for most makes and models of automobiles.

Until recent years, the average refiner had little difficulty in supplying motor fuels that satisfactorily met the octane requirements of automotive engines. However, the continuing trend toward higher compression ratio engines has made this task increasingly difficult. Only through substantial investments for the refining facilities required to take advantage of technological advancements in processing and fuel component blending has the industry been able to meet this need. Even so, the present situation is such that small increases in fuel quality requirements will be of immediate economic concern to the refiner. Thus, it is apparent that test methods for octane number determinations must yield highly precise results.

This high precision requirement in the rating of motor fuels has brought into sharp focus certain limitations inherent in present knock test methods. Among these are (1) variations between test engine cylinders, (2) the effect of changes in barometric pressure, (3) the nonuniform scale of expression, (4) instrumentation for tracking detonation, especially in the range above 100 octane, and (5) carburetion.

The need for more precise knock testing methods and equipment has been recognized for some time. The industry has presented to both API and ASTM the economic justification for the required improvements. In method evaluation studies ASTM Research Division I has shown that duplicate octane ratings might differ by as much as 1.2 to 3.0 octane numbers, depending upon octane level and the type of fuel being rated. In view of what the future portends, it is gratifying to note that some improvement in test precision is being effected by the rating of fuels against prototypes, by multiple testing, by test engine modifications (notably improved instrumentation), and by application of the temperature-density concept advanced by the Sinclair Refining Co. Nevertheless, there remains considerable incentive for further improvements in octane rating reliability; to this end, the activities of Research Division I will be accorded widespread interest.

Petrochemical Testing Problems

The foregoing summary of the status of motor fuel octane ratings is typical of current analytical and testing problems. Time, obviously, will not permit a complete listing of such problems, even if restricted to fuels alone. Instead I should like to turn now to the testing problems in the remarkable and rapidly expanding field of petrochemicals. This field has grown, and is growing, so rapidly that the backlog of needed standard methods of test shows no signs of diminishing.

It is my understanding that Section I, of Technical Committee H on Light Hydrocarbons for Chemical Utilization, has recently completed a survey of the tests required for a number of hydrocarbons ranging from ethylene to C_8-C_{10} olefins. As a result of this survey, limits of precision for the ranges of interest have been established. This is certainly an excellent beginning, but much work remains to be done. Illustrative of the over-all situation is the case of polymerization grade ethylene. The lack of ASTM Standards for trace contaminants has necessitated extended laboratory investigations and prolonged negotiations between producer and customer before agreement on specifications and test methods could be reached. The situation with regard to ethylene contrasts sharply with that of petroleum-derived benzene. For those refiners who have only recently entered the aromatics market with this petrochemical, the availability of ASTM standards relating to the measurement of freezing point and the determination of purity therefrom has been of invaluable assistance. While I realize that these two situations may not be directly comparable, they re-emphasize the value of a recognized standard—an ASTM Standard.

In connection with the survey conducted by Section 1 of Technical Committee H, I should like to point out that propylene was not included in the list of hydrocarbons selected for study. The present interest in, and the predicted demand for, propylene for polymerization purposes highlight the coming need for standard methods of test for trace-contaminants therein. While there is a strong possibility that any method developed for ethylene will be equally applicable to propylene, any assumption to this effect will require confirmation.

The field of petrochemicals is, as noted earlier, not limited to hydrocarbons alone. In some instances, petroleum refiners have found it expedient and profitable to utilize conversion processes for the production of a chemical or chemical intermediate. The aromatic acids, either monobasic or polybasic, are typical products in this category. Undoubtedly, as more refiners enter this field, ASTM will be called upon to supply standard methods of test.

Before I leave the subject of analytical and testing problems facing the refining industry, one other matter deserves mention; this concerns additives analyses. The ability of certain materials in small concentrations to impart desirable quality characteristics to many petroleum products is widely recognized and utilized. At present, gasolines, heating oils, and lubricating oils—to name just a few—make use of additives. There is little doubt that the applications of additives will continue to grow, and while the field is a rapidly changing one, eventually standard methods of test will be necessary.

In conclusion, I should like to recognize again the value of ASTM to the petroleum industry. When we reflect that the quality of our products, which influence the growth of our enterprises, are measured to a large extent by standard test and analytical methods, the services rendered by ASTM in the past are clearly delineated. The achievements of this organization have been truly outstanding and in a manner benefitting producers, consumers, and general-interest parties. Continued prosecution of its activities in the manner that has accomplished so much in the past need only be balanced with the vision to anticipate future requirements. to enhance, still further, ASTM prestige.

STANDARDS AND THE NEW SCIENCE OF MATERIALS

By C. A. HOCHWALT

The present performance requirements of engineering materials have taken industry to the threshold of a new era in the science of materials, necessitating a change to standards based on fundamental properties, not secondary characteristics, of materials—according to Carroll A. Hochwalt, vice-president for research, development, and engineering, Monsanto Chemical Co., at the Chemical Industry Luncheon of the 1958 ASTM Committee Week at St. Louis

MONSANTO Chemical Co. was founded in 1901 by businessmen and chemists, and our initial goal was to make chemical products. ASTM was incorporated about the same time (1902), by civil and mechanical engineers principally, with standardizing of test methods and specifications as one of its goals. For nearly thirty years Monsanto and ASTM developed and grew in their separate paths, through good years and bad, without ever finding much common ground.

Our first product was an organic chemical, saccharin, the first of a long line of organic and inorganic chemicals. Until 1938, the company was in the business of manufacturing fairly simple molecules. These were sold on the basis of purity, chemical analysis, and chemical properties, that is, % C, % H, % O, melting point, boiling point, acidity, etc. Frequently, the product was an intermediate in our customer's manufacturing processes. At this stage in our history, specifications were simple and were easily defined in chemical terms. Standards were more important to us as a purchaser of chemical process equipment than as a supplier of engineering materials.

During these years ASTM developed its unique approach to cooperative standardization, involving the democratic participation by producers, consumers, and general interest representatives. Materials of construction—steel, concrete, masonry, paint, non-ferrous metals—were its chief concern, and test methods involved mechanical properties, physical constants, and chemical analysis. Few materials of direct interest to the ultimate consumer ever came within its ken.

Throughout these years our paths were parallel but seldom converged.

Performance Requirements Prevail

In 1938 Monsanto took a step which was to change the character of our business; we got into the materials-of-construction business when we began to manufacture giant molecules, that is, high polymers or plastics. In addition to selling chemical compositions, we now found ourselves selling package per-

Continued on next page

CARROLL A. HOCHWALT, vice-president for research, development, and engineering and a member of the Board of Directors of Monsanto Chemical Co., is also a member of the company's Executive Committee. In 1926 with his friend, Charles Allen Thomas, now president of Monsanto, he organized the Thomas and Hochwalt Laboratories, at Dayton, to do general research and consultant work for the chemical industry. In 1936 the laboratories were acquired by Monsanto and became known as the company's Central Research Department. More than 70 patented discoveries have been made by Dr. Hochwalt in his research on such subjects as dialkyl selenides and tellurides, phosphates, fire extinguishers, dehydrated nitrocellulose, fermentation, polymers, petroleum refining methods, and liquid phase oxidation. During World War II, he was actively engaged in the work of the Manhattan District project and in the work of the National Defense Research Committee, serving as a consultant and section member in connection with the development of solid propellents. He is a member of the Ordnance Advisory Committee of the Army's Research and Development Division.

formance. We were selling physical, chemical, and mechanical properties. No longer was a per cent purity figure significant. We had to guarantee, for example, certain levels of tensile strength, minimum moduli of elasticity, maximum dissipation factors at given frequencies, and stated optical properties. Color, weather resistance, and similar hard-to-define characteristics had to be assured.

For chemists this was at first both an intriguing and somewhat terrifying experience. We managed to survive this transition by putting chemists to work with engineers and physicists, by learning to think in terms of end-product performance, and by developing a position in product engineering. To further complicate this situation, during these years the entire plastics industry was experiencing the painful transformation of polymer technology from an art to a science.

During these years Monsanto's and ASTM's paths converged with fusion velocity and have remained intermingled ever since. Our participation in ASTM, developing methods for testing plastics, carrying on research on their properties, and setting up reasonable standards, was of great help to us then as it is now in this and other areas of our business. As a matter of fact, Monsanto's entry into the plastics business almost coincided with the formation of Committee D-20 on Plastics, and the names Wilson, Carswell, Telfair, Nason, Adams, Debing, Ingle, Hayes, and Craver are familiar to the "oldtimers" in Committee D-20 as Monsanto contributors during the early days. Thus, Monsanto has been a strong proponent of the ASTM for over twenty-five years, and today 40 of our people serve on 25 different main committees of the Society.

Dawn of an Era—

The New Science of Materials

The main point I want to make, however, is that ASTM and its member participants, Monsanto included, stand on the threshold of a new era in our experience, an era which will bring greater changes than any we have seen before and which will reshuffle our technologies at a rate of speed which will be terrifying if we are not braced for it. This era is being brought into being by what I call *the new science of materials*.

Let me illustrate what I mean by rate of change. The horse and buggy era was good for 2000 years, until displaced by the automobile in the second and third decades of the Twentieth Century. This gasoline-powered, rubber-tired successor, will do well to last out the century as a prime means of transportation. Piston-engine powered aircraft reached their highest stage of development in 1957; thus an era of development which began with the Wright Brothers at Kitty Hawk now is nearing its end. The jet age, begun in the military field in 1944, begins its domination of commercial transportation during 1958. The satellite age now is five months old. How long will it be before the antigravity machines of "science fiction" will make the Sputniks and our own Explorer obsolete? Shorter than most of us would like, I suspect. Perhaps perspective is enhanced by the observation that an Atlantic crossing in 1620 on the Mayflower took two months; 1860 on the Great Eastern, two weeks; in 1952 on the United States, four days; in 1957 on a DC-7C, nine hours. In 1959 on a 707 or DC-8 this voyage will take 300 minutes, and in 19xx, via the passenger-carrying rocket, 600 seconds.

Complexity Grows with Technology

Coupled with the rapid pace of the development of new technology is its high degree of complexity, related to highly automated processes of all kinds, to new and novel materials and combinations of materials, and to new methods of fabrication.

The creation, testing, application, and understanding of these new materials, methods, and procedures comprises the new science of materials. It brings with it new skills, new talents, new viewpoints—even a whole new language. We do not talk of horsepower anymore in rating jet engines, nor even of ergs, foot-pounds or kilowatts; we speak of "thrust." Nor do we rate rocket engines in terms developed when animal muscle power was the basic unit; we rate them in terms of "specific impulse."

Similarly in materials, we are dealing with the exotic issue of a fruitful technology: titanium, zirconium, hafnium, germanium, selenium, tellurium, columbium—to name but a few of the more direct descendants. Cermets, polymers, glass-plastic and other combination materials, intermetallics, illustrate more complex developments. Not even stoichiometry is inviolate to this new science; combinations which defy our old theories of valance are common—$TiCl_3$, $KFeO_4$, Ag_2O_3, and $K_4Ni(CN)_4$, for example. New metals, new combinations, new synthetic materials, all combined and recombined in new ways, make possible new devices and new effects.

Neither are we always concerned with the familiar properties, in whose use we have become so comfortably adept in years past. In components for an intercontinental device—be it jet airliner or missile—coercivity and remanence may be more critical than tensile strength and ductility; the nuclear cross-section in, "barns," may be more important than the impact-strength in foot-pounds.

Electronics Open New Horizons

Electronics has contributed in many ways to revolutionizing our technology. It has created a need for new materials and new methods of testing, of course. But it also has made possible control devices, testing apparatus, computational capabilities, and communication potentials which never existed before and to which some of us have difficulty in adapting our thinking processes. Literally, it is hard for man today—and especially for us "older" men—to "keep up with the machine."

Testing methods, too, and the specifications which employ them, are different. The critical concentration of boron in electronic-grade silicon is measured in parts per billion and is established by electronic tests, not chemical tests. And this brings us to another characteristic of the new science—purity; we are dealing with compositions more critical by orders of magnitude than those with which we have been concerned in the past.

New Materials Stem from Knowledge of Fundamental Properties

Finally, this new science of materials involves new professional disciplines. To the chemists, physicists, and engineers on our committee research and standardization teams, we now must add specialized personnel, derivatives of the older, more generalized professions.

For in the new science of materials we are dealing in molecular, atomic, and subatomic phenomena, and it is the understanding of these—and their manipulation to meet our new needs—that distinguishes this area as a radical development in materials technology. It is with these that the ASTM committee work of the future will be most deeply concerned.

To adapt quickly to this new situation is the greatest challenge confronting this Society.

We shall continue to need standards, despite the complexity of the new techniques. We all know how important standardization is to the industrial might of our nation. In common with other aspects of our technology, its role now is a more demanding one than ever. But we shall need new kinds of standards, and we shall need to produce them much more promptly. To keep abreast, standards are needed for the materials of today—not for those of yesterday.

New Standards Must Define Fundamental Properties

Let's for a moment, address our remarks to the problem of speeding up the standardizing procedure as practiced

within today's ASTM frame of reference. The pure democracy of the standardizing operation—an element, at times, of frustration and delay—should most definitely be retained. I feel, though, that much in the way of streamlining, with a consequent significant reduction in standardizing time, could be achieved through a thoughtful study of the mechanics. One rather obvious way to develop standards at a faster pace is to put more people to work on a full, rather than a part-time basis. This means a greater financial commitment by producer, consumer, and general interest members of the Society. But this should be devoted primarily to the research aspects of the problem, so that the results rest on a more firm technical foundation. To meet the new needs, standards are going to have to define fundamental properties, not arbitrary secondary characteristics. And knowledge of these, plus sound techniques for defining them, comes only from research.

Another factor in what appears to be the leisurely pace at which methods and specifications develop is the "practical" level of technology that apparently has to be adhered to. Thus, where advanced techniques and instrumentation resulting from basic research efforts form the foundation for a standard, these now usually are compromised to make the standard generally usable by the industry, by those with limited facilities and skills, as well as by those adequately equipped. This not only adds months, and sometimes years, to the promulgation of the standard, but frequently detracts from its quality and usefulness.

Another roadblock that is encountered is the lack of basic information to define a material with sufficient accuracy to draft a specification. A case in point is polyethylene. In production since early in World War II, the specification covering this material did not appear on the ASTM books until 1952. The delay was partly due to the fact that the apparently simple ethylene polymer molecule was not sufficiently understood.

No doubt many have done a great deal of thinking about tomorrow's standardization in the light of the problems already mentioned. As we see it, the standardization work of tomorrow will lean very heavily on the rapid advances that are being made, and that will continue to be made, in "molecular engineering," that is, in the physics, chemistry, and engineering of the ultimate structure of materials.

Tomorrow's Standards—*Equations of State?*

Perhaps the target of tomorrow's standard should be an equation of state, or, perhaps, equations of state. Into an equation of this nature will go the molecular and atomic parameters of a given composition of matter. Ideally, out of it will come the precise strength at a given temperature, at a given loading rate; the dielectric properties at a given frequency; the thermal properties and other data necessary to complete definition of the engineering behavior of the material. The target is a lofty one viewed from today's qualitative "materials science" platform. It is probably one of the most challenging technical problems which engineering has ever faced. When solved, standardization will be able to move as rapidly as the technology it serves. In the meantime, each advance in materials science will have a significant and beneficial effect on standards. A side reaction of the materials science - standardization interplay, is that specifications will be indicative in the future, not only of quality, but also of engineering performance.

The specification of tomorrow may be a very simple one by today's standards. Conceivably it could describe molecular type, size, and atomic geometry in terms of a very few numbers. It could originate with the scientist or engineer who in defining the performance requirements for a material would specify the fundamental atomic and molecular parameters. Because of the quantitative nature of his specification, reflecting the advancement of materials engineering to an exact science, standardizing bodies could act immediately. Long, frustrating, and expensive round-robin test programs would become ancient history.

ASTM Meets the Challenge

The objective of ASTM contains strong research overtones. Though known for its work as a standardizing body, it publishes each year more words telling of new knowledge on materials than it does of words relating to new standards. It stresses the importance of materials research through awards recognizing significant scientific achievements. Another source of research stimulus is the Administrative Committee on Research. This group, while administering research grants, seeks to promote research on materials through its column "ACR Notes" in the BULLETIN and contacts with the technical committees. In the light of the preceding discussion, I should like to suggest that the Administrative Committee on Research might play a leading role in promoting these concepts among the technical committees, since, in the final analysis, it is among them that the real work of the Society is done and it is from them that the initiative must come for any radical revisions in our procedures and performance.

Education Meets the Challenge

Incidentally, some of our leading technical schools are alert to the challenge of the new science of materials and are seeking improved curricula which would train engineer-scientists who will understand the relationship between atomic and molecular structure and forces on the one hand and properties of a composition of matter on the other, and who will be able to put this knowledge to practical use in the synthesis of new materials and in their fabrication into useful engineering structures and devices. Illustrative of this trend are the comments of L. A. DuBridge, president of the California Institute of Technology, in that fine school's annual report of December, 1957:

> We. . .are carrying a large content of advanced physics and mathematics into the graduate engineering programs. The research engineer of today and of tomorrow will have to be quite at home with set theory, Boolean algebra, quantum electrodynamics, the quantum theory of metals and semiconductors, and many other erudite matters formerly unheard of by the practical engineer.

This may be the materials engineering education of the future. It would require a depth of education, in chemistry, physics, mathematics, and related sciences, far beyond that which is available today to the engineering graduate.

In summation, I should like to repeat that we stand on the threshold of a new science of materials, and that we are experiencing the first engagements of the revolution which that development is producing. This will profoundly affect ASTM as well as the chemical and allied industries and will require a new approach to standardization if the Society is to continue its eminent position in this area.

Power Separation Filter for Corona Testing

By NETA P. SHEPS

One of the problems in the operation of electrical equipment at high voltages is that of corona, the ionization of the insulating media. Corona gives rise to high-frequency noise and also causes deterioration of organic insulation which in time will result in an electrical breakdown. In equipment used for communication purposes the presence of corona noise can cause a serious reduction in efficiency, and therefore it is desirable to have the apparatus free from corona at the operating voltage.

Communication equipment of the wide band coaxial type used in the Bell system uses the same cable to supply power to the repeater and to carry the high-frequency signals. In order to check the system for the presence of corona noise a special test set has been developed (Fig. 1). Part of this corona test set is a power separation filter (PSF) required to supply noise-free 60-cycle high voltage to the equipment and simultaneously separate the high-frequency corona noise generated in the equipment from the 60-cycle test voltage.

In making corona tests on equipment such as coaxial cable, a large charging current is required because of the high capacitance to ground. The PSF, therefore, must simultaneously supply this current and provide high attenuation over a frequency range from about 100 kc to 8 Mc to any noise frequencies which may be present in the power source. Since the noise due to corona is measured over the same range (100 kc to 8 Mc), the filter must also provide low attenuation over this range between the equipment under test and the measuring circuit and high attenuation at 60 cycles (Fig. 2).

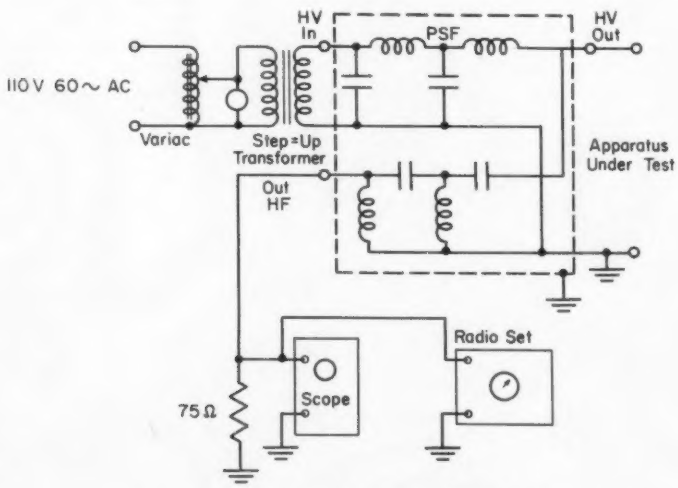


Fig. 1.—Circuit diagram of the corona test set.

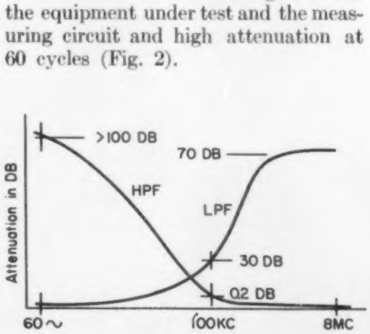


Fig. 2.—Attenuation characteristics of the corona test set PSF.

The PSF, consisting of a high- and a low-pass filter in parallel at the equipment end (Fig. 3), will carry a steady current of 0.5 amp at 10 kv.

The special performance of this filter is made possible by the type of components used (see Fig. 4 for components assembled in can). The capacitors that are subject to high voltages are special oil-impregnated paper designs that have small parasitic inductances effective from 50 kc to 8 Mc and are corona-free up to maximum voltage. The inductors are an air core type design free of resonances and antiresonances up to 8 Mc. They carry the maximum operating current of approximately 0.5 amp while withstanding a momentary surge due to failure of the equipment under test.

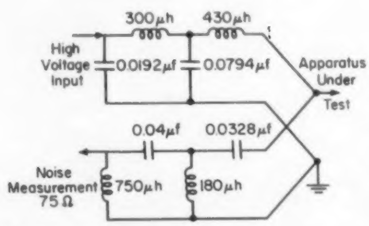


Fig. 3.—Schematic of the corona test set PSF.

NETA P. SHEPS received a Bachelor of Science Degree from Upsala College in 1951 and joined Bell Telephone Laboratories in the same year. Since then she has been concerned with the design and testing of frequency selective networks used in various long distance communication systems including the Havana-Key West submarine cable system of the USAF Missile Test Center.

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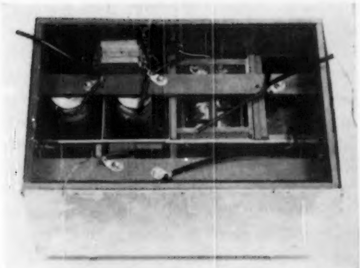

Fig. 4.—Power separation filter for corona test set showing assembly of components.

The filter is housed in an oil-filled metal can $6^1/_8$ by $8^1/_4$ by $12^1/_4$ in. (not including terminals) as shown in Fig. 5. It is provided with two high-voltage bushings for the test voltage input and equipment connections and a low-voltage bushing for the measuring circuit, while the filter case provides the ground connection.

The corona test set provides effective means of measuring corona under a wide range of conditions. Prior to the development of this PSF only low-current, high-impedance devices could be measured over a narrow frequency band. Now, the power handling capacity of the test set has been considerably broadened as well as the frequency range over which corona may be detected.

Acknowledgment:

The author wishes to thank E. W. Holman for the information and advice he gave.

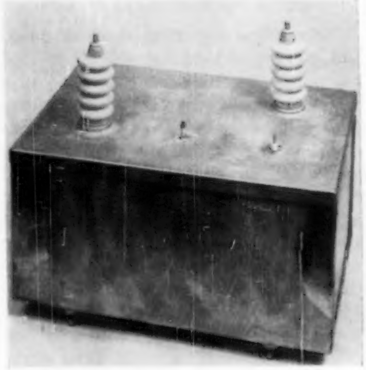

Fig. 5.—Power separation filters for corona test set—external view.

In-Place Density Tests

*of Cohesionless Coarse-Grain Base-Course Material**

By DONALD F. GRIFFIN

Reasonably accurate in-place density measurements of base-course materials could serve useful purposes. Various types of compaction equipment could be evaluated according to their effectiveness of compaction, and known in-place densities could also serve as criteria for stability of the material in place.

In order to evaluate the error of in-place density measurements it is first necessary to determine the order of accuracy of the apparatus used to measure the in-place density *per se*. The sand cone apparatus has long been used to measure in-place densities of soils and is widely accepted for this purpose. Very little information has been published about the accuracy with which this device may be used. Therefore, evaluation of the sand cone apparatus constituted a part of this research project.

In any graded soil it is to be expected that true densities would vary from place to place within the soil mass and that significant variations from true average density could occur within a relatively small volume of soil. Chance arrangement of soil particles, chance selection of sizes and shapes of particles at a given location, differential amounts of energy of compaction, and differential water contents would all contribute to local variations from true average density. Several tests taken as a group should therefore give more reliable results than would the results of individual tests.

A box of known volume in which a minimum of four tests could be performed was selected as the method of determining the true average density of a given soil mass. Results of tests with known error in procedure or technique were discarded. Deviations of measured values from known average values on the basis of four tests per box were, therefore, relatively free from error due to operational procedure and, consequently, these deviations must be due to changes in volume of the soil with sampling, assuming that four tests are representative of average conditions in the box. The magnitude of these volumetric changes depends upon the initial density as well as upon the water content of the soil.

DONALD F. GRIFFIN, director, Materials Division, U. S. Naval Civil Engineering Research and Evaluation Laboratory has done extensive research in the field of in-place density measurements of soils. He is a member of ASTM Committee D-18 on Soils for Engineering Purposes.

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Volumetric Measurement of Cavities

Currently accepted methods of measuring in-place densities of soils involve the measurement of the volume previously occupied by soil excavated from the cavity. The more feasible methods of measuring volume are by means of a water balloon apparatus or by means of filling the cavity with calibrated sand in a specified manner. The author has conducted some unpublished research on the water balloon method using three different water balloon devices. Experiments showed that a glass jar could be completely filled with a balloon expanded with water when using string to bleed off air that would otherwise be trapped below the balloon. A string, lining a vertical cross-section of a cavity was used to bleed off air and allow the balloon to expand fully into the cavity. The general findings were that the balloon method is quite accurate for measuring so-called optimum volumes for the particular device. Volumes other than optimum were measured with considerable error. Device No. 1 ranged in error from a minimum of 0.20 per cent for optimum volume up to nearly 4 per cent for other volumes. Device No. 2 ranged in error from a minimum of 1.41 per cent to nearly 5.5 per cent and device No. 3 ranged from a minimum error of 0.40 to a maximum of 2.76 per cent. All volumes measured were within the capacity of the particular device used.

In base-course materials it is not possible to estimate with any reasonable degree of accuracy the volume of a cavity at any time during the excavation process. Therefore, it is desirable to use a method of measuring volumes that is relatively independent of the size and shape of the cavity. The sand cone method appears to fulfill this requirement better than the balloon method.

A gallon jug with sand cone and supporting plate was used to measure the volumes of cavities from which base-course material was excavated. These volumes approximated 100 cu in. with a maximum diameter of about 6 in. Graded Ottawa sand (ASTM Method C 109)[1] was used in the sand cone apparatus. It has been found by the author to give slightly better accuracy than the ungraded Ottawa sand (ASTM Method C 190)[2]. The sand cone apparatus was calibrated for volumetric measurements in cavities of known volume reproduced from actual cavities in Montalvo base-course material.

Fig. 1.—Cavity in simulated Montalvo base course material.

Base-course material was compacted in a wooden box. Cavities of various volumes were excavated as if for in-place density tests and then filled completely with a mixture of melted paraffin and heated Ottawa sand. The sand reduced the quantity of paraffin required to fill each cavity and this in turn reduced the volumetric shrinkage of the paraffin upon cooling to a negligiable amount. Good sharp casts of the cavities were thus obtained. These casts were carefully removed by excavating the soil from around them, and adhering soil particles were removed by carefully prying embedded grains loose and washing the casts with water. They were then surface dried, inverted in 5-gal cans, and sealed to the bottom with additional paraffin. The casts were then covered with a mixture of S.S. White Albastone, Ottawa sand, and water. After the Albastone had set, the metal containers were removed. Each cast of paraffin and sand was removed from the Albastone by heating the entire mass in an oven at 215 F. The resulting cavities were sharp and clean and were quite faithful reproductions of the original cavities. One of these is illustrated in Fig. 1.

The cavity interiors were given three coats of acrylic spray for waterproofing. Each cavity was then filled with distilled water at known temperature and the volume of each was then computed according to the weight of the water and its density in g per cu cm. These volumes are considered to be the most probably correct volumes that could be measured by any method.

The sand cone apparatus was calibrated according to the Griffin method as first reported in the ASTM BULLETIN in February 1956 (**3**)[3]. This method had been proved to be highly accurate for cavities in the shape of smooth brass cylinders but had not been proved for irregular cavities such as those in base-course materials with their many indentations and protrusions. The total weight of sand leaving the gallon jug including the sand in the cavity, the sand in the opening of the supporting plate, and the sand in the cone below the valve opening of the jug, was determined as the average of ten trials for each cavity. Results of these tests are tabulated in Table I. The maximum probable error for a single measurement of the total amount of sand leaving the jug for any individual cavity was computed to be 0.114 per cent for sand cone No. 1 and 0.155 per cent for sand cone No. 2. The actual maximum deviation from the mean for any single cavity measurement was found to be 0.41 per cent for sand cone No. 1, and 0.28 per cent for sand cone No. 2.

TABLE I.—WEIGHT OF GRADED OTTAWA SAND LEAVING JUG FOR SIMULATED MONTALVO BASE COURSE CAVITIES.
(Results for 10 tests in each cavity.)

	Cavity Volume, cu cm			
	Zero[a]	276	852	1622
SAND CONE APPARATUS No. 1				
Maximum weight, g	1794	2208	3063	4225
Average weight, g	1791	2199	3058	4221
Minimum weight, g	1787	2193	3054	4219
SAND CONE APPARATUS No. 2				
Maximum weight, g	1787	2204	3074	4233
Average weight, g	1782	2201	3069	4226
Minimum weight, g	1777	2197	3065	4216

[a] Cone and supporting plate.

All of the cavities listed in Table I had surface openings smaller than the circular opening of the supporting plate. Three additional cavities had surface openings larger than the circular opening in the supporting plate which was 6.5 in. in diameter. The diametrical openings in the three larger cavities ranged from 7.75 in. maximum to 6.5 in. This would represent what may be termed as undercut condition, that is, an excavation extending laterally beneath the supporting surface of the plate. Data for these cavities are shown in Table II for sand cone No. 1.

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[1] Method of Test for Compressive Strength of Hydraulic Cement Mortars (C 109 – 56), 1955 Book of ASTM Standards, Part 3, p. 129.

[2] Method of Test for Tensile Strength of Hydraulic Cement Mortars (C 190 – 49), 1955 Book of ASTM Standards, Part 3, p. 188.

[3] The boldface numbers in parentheses refer to the list of references appended to this paper.

TABLE II.—WEIGHT OF GRADED OTTAWA SAND LEAVING JUG FOR UNDERCUT CAVITIES IN SIMULATED MONTALVO BASE COURSE MATERIAL SAND CONE APPARATUS NO. 1
(Results for 10 tests in each cavity.)

	Cavity Volume, cu cm			
	Zero	1705	2017	2528
Maximum weight, g.....	1794	4315	4759	5540
Average weight, g.....	1791	4307	4744	5522
Minimum weight, g.....	1787	4290	4740	5503

The maximum deviation from the mean for any single cavity was found to be 0.34 per cent.

A plot of the total weight of sand leaving the jug *versus* volumes of the cavities shows a straight-line relationship as indicated in Fig. 2 for sand cone apparatus No. 1, and the formulas of the following type can, therefore, be used to compute the volume measured according to the weight of sand:

Sand Cone No. 1:
$V = (W\text{-}1791)(0.6674)$
$V = (W\text{-}1791)(0.6774)$...(undercut)
Sand Cone No. 2:
$V = (W\text{-}1782)(0.6636)$

where:

V = volume, cu cm, and
W = weight of the sand cone apparatus with the jug full of sand less the weight of the sand cone apparatus with residual sand after filling the cavity, g.

The initial weight of the sand cone apparatus with the jug full of sand was kept constant at 7850 g and the equations could, therefore, be set up for use with the final weight only. The equation for the undercut cavities is not suggested as being reliable under general conditions. The degree of undercut was not excessive for the three cavities involved. With an increasing amount of undercutting there would be a decreasing order of accuracy. It has been shown in a previous work (**1**) that sand will not fill that portion of a cavity beneath the supporting surface of the supporting plate and immediately adjacent to the circumferential opening. With undercutting, the volume of the cavity is measured too small and the computed density is, therefore, too great.

The order of accuracy of the sand cone apparatus may be observed on a practical basis by computing the volumes of the cavities, using both minimum and maximum values of total sand leaving the jug as given in Table I. The results of such calculations are shown in Table III. The maximum errors for each cavity are 2.9 per cent, 1.1 per cent, and 0.4 per cent, with the smaller errors for the larger cavities. All the actual cavities used in the in-place density tests exceeded 1000 cu cm, allowing a maximum error, therefore, of about ±1 per cent due to the apparatus alone. The source of error in the sand funnel is due primarily to chance arrangement of sand particles and chance packing in the jug. In each of the three cases, the actual maximum variation in computed volume *versus* true volume was 8 cu cm, 9 cu cm, and 7 cu cm, respectively, for the above percentage error figures. Since the error is more or less constant in itself it is high in relation to a small volume.

It is assumed that the sand in the jug would be in an oven-dry state. The presence of moisture in the sand would certainly influence the results. Also, it is assumed that the operator would wait a few seconds, preferably a minimum of 10 sec, before closing the valve after the flow of sand from the jug had apparently stopped (**1**).

TABLE III.—VOLUMES OF CAVITIES COMPUTED BY EQUATIONS COMPARED TO TRUE VOLUMES OF CAVITIES, CU CM.

Sand Cone Apparatus No. 1		Known Volume	Sand Cone Apparatus No. 2	
Maximum Volume	Minimum Volume		Maximum Volume	Minimum Volume
278	268	276	280	275
849	843	852	857	851
1624	1620	1622	1626	1615

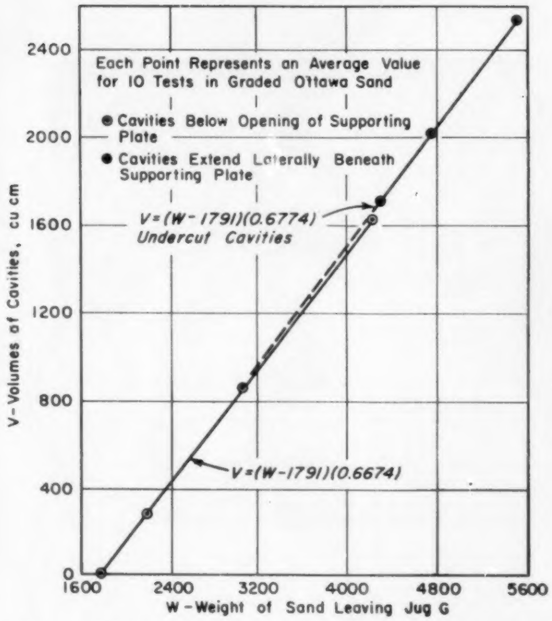

Fig. 2.—Cavity volumes *versus* weights of sand leaving gallon jug (sand cone No. 1).

Montalvo Base-Course Material

Montalvo base-course material comes from the bed of the Santa Clara River near Montalvo, Calif. In general appearance it is essentially a cohesionless mixture of rock and sand. One sieve analysis gave the following grain-size distributions:

Sieve Opening, mm	Per Cent Passing
38.1..............	100
26.67.............	89
18.85 (¾ in.)......	75
9.423.............	48
4.760.............	32
3.327.............	29
2.362.............	27
2.000.............	26
0.840.............	20
0.590.............	18
0.420 (No. 40)....	14
0.246.............	10
0.104.............	7
0.074.............	6

The maximum density for optimum water content by the modified Proctor test on the minus ¾-in. material was 128.32 lb per cu ft with a water content of 6.75 per cent. The specific gravity of a 1000-g portion representative of all sizes of material was 2.64. The maximum density obtained in the test box including all sizes of particles was 2.134 g per cu cm or 133 lb per cu ft. It is believed that the minus 40 material was predominantly nonplastic, although seg-

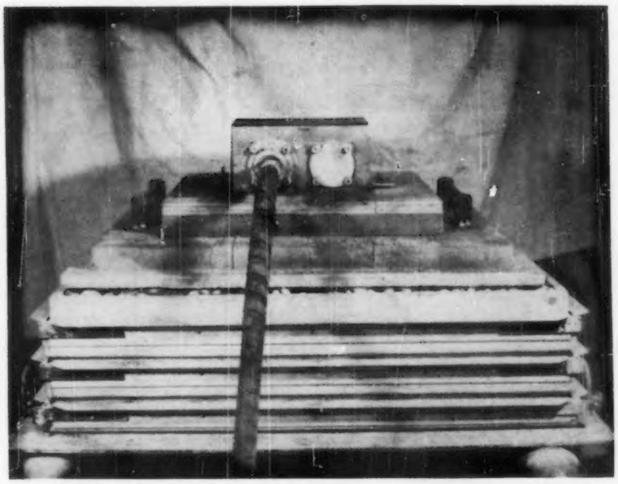

Fig. 3.—Lazan oscillator mounted on base plate in test box.

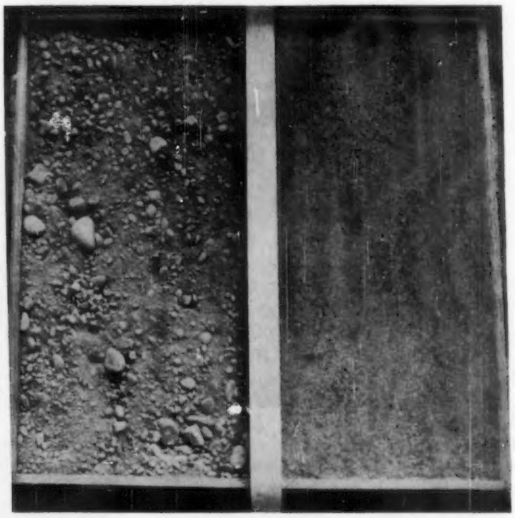

Fig. 5.—Test box with left half screeded and right half tamped with fines and ready for testing.

regated portions were plastic. The plastic limit for one sample was 14 per cent and the plasticity index was 4 per cent. Several other samples of the minus 40 material were non-plastic.

Control Densities

A reinforced marine plywood box 3 by 3 ft in plan was used as the control volume. This box was constructed in interlocking layers each 3 in. high. Enough base course material was mixed in a 14-cu ft concrete mixer to fill four layers of the box loosely. In the initial stages of testing, water was added to approximately every fourth box to increase the water content gradually. When the water content reached about 8 per cent, no more water was added and the material dried out with continued use. Additional water was then added or the material was allowed to dry in order to provide a water content that was particularly desired for testing. A range of control densities was obtained as follows.

Mixed base-course material was discharged from the mixer onto a short conveyor belt unit and emptied from the belt directly into the test box. For loose densities, the material was shoveled into place as it fell from the belt. For intermediate densities, the material in the box was vibrated with a Lazan oscillator as illustrated in Fig. 3. The mass was vibrated in either one or two lifts, the latter generally but not always giving the greater densities. Very dense material was obtained by the use of a pneumatic air tamper applied either to one or two lifts of the material as illustrated in Fig. 4. The compacting shoe of the tamper was about 5.5 in. in diameter.

After compaction, the top layer of the box was removed and the excess material struck off with an aluminum bar. The bar is shown in Fig. 5 as the dividing strip between the surface as struck off and the surface subsequently prepared for testing. Excess material was screened through the finest sieve feasible to use which in turn depended upon the water content of the material. For relatively dry material, the No. 4 sieve was used, and for wet material the $\frac{3}{4}$-in. sieve was used. The material passing the sieve was tamped into the surface voids of the material in the box by means of one face of the aluminum bar. Attempts were made to place this material at nearly the same density as the material in the box.

Fig. 4.—Compacting base course material in test box with pneumatic tamper.

At water contents up to about 2.5 per cent, the material appeared dry and dusty. At slightly higher water contents the material definitely appeared moist. At water contents between 4 and 6 per cent, the material looked quite wet. After the water content reached approximately 7.5 per cent, the material acted as a highly plastic mass. It assumed a high density as it was placed into the test box and tamping or vibrating had little or no effect on increasing the density. Although the density was high, the support or bearing capacity of the material was obviously low as plastic flow could take place easily under surface loading. With low water contents it was not possible to obtain the higher densities, and with relatively high water contents above 6.5 per cent it was not possible to place the material with a low density. All densities are based on dry weight.

In-Place Density Measurements

The moist control density was determined by weighing the entire box and contents on a set of Toledo scales reading direct to the nearest pound. Four tests were made in each box of base-course material. Each sample was weighed on a Toledo scale reading direct to 5 g. For in-place density tests, the

entire sample, including coarse rocks, was dried in an oven at 110 C. The total water content of the four samples per box was used as the average water content of the box. The dry control density was determined by dividing the original wet weight of the soil in the box by 1 plus the water content ex-expressed as a decimal. The volume of each cavity was determined by means of the sand cone apparatus used with supporting plate. The volumes were computed according to the calibration equations previously presented; however, no corrections were made for undercut cavities. The undercut condition was treated as a natural source of error since the degree of undercutting was not constant for all undercut cavities.

The density measured by the sand cone apparatus was determined both for individual tests and for the four tests per box as a group, by taking the total dry weight of soil excavated and dividing by the total volume computed. Results for all tests are tabulated in Tables IV, V, and VI. Densities for individual tests varied widely for the four tests made in a given box. The water contents for four individual tests per box varied to some degree, but for the most part they were fairly uniform. The combined results of four tests is considered to be the in-place measured density for a given box. The sand cone apparatus together with tools used for excavating cavities are shown in Fig. 6.

Conclusions

Two observed phenomena are conclusive. At water contents below 2.5 per cent, the base-course material is essentially cohesionless. During the excavation of a cavity, material from the cavity walls sloughed off and the walls appeared to expand into the cavity. Thus, volumes were measured too small and densities were computed too high. At high water contents, the soil acted as a plastic mass and at about 8 per cent water content the soil mass was almost fluid. When a cavity was excavated in the soil with such a high water content, plastic flow tended to fill the cavity and again measured volumes were too small, giving computed densities that were too great.

Between these two extreme conditions, there were varying degrees of change in volume caused by the effects of shear during sampling. At increasing densities with water contents between 3 and 7 per cent, the material was increasingly able to resist deformation with sampling. In Fig. 7 are plotted test data showing trend lines according to water contents of percentage deviation of densities measured by the sand cone

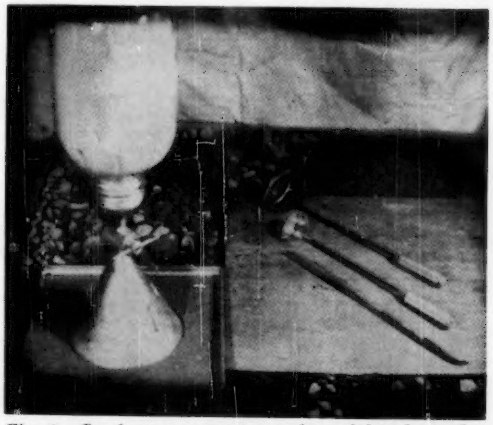

Fig. 6.—Sand cone apparatus and special tools used to excavate cavities in base course material.

TABLE IV.—DENSITY MEASUREMENTS.

Box	Control Density, g per cu cm	Measured Density for Individual Tests, g per cu cm				Average Group Density, g per cu cm	Group Water Content per cent
1...	1.711	1.865	1.591	1.757	1.600	1.705	3.053
2...	1.767	1.746	1.853	1.784	1.839	1.810	3.145
3...	1.854	2.095	2.084	1.958	1.935	2.031	2.116
4...	1.871	2.100	2.073	2.021	2.074	2.071	2.152
5...	1.966	2.000	2.078	2.129	2.030	2.057	2.174
6...	1.932	2.064	1.966	2.049	2.078	2.037	2.605
7...	1.742	1.864	1.814	1.940	1.771	1.845	2.587
8...	1.791	1.912	1.944	1.927	1.916	1.924	2.469
9...	1.919	2.028	2.081	2.060	2.013	2.044	2.264
10...	1.878	1.969	1.948	1.977	1.912	1.962	1.779
11...	1.765	1.586	1.805	1.812	1.745	1.738	2.565
12...	1.690	1.757	1.712	1.781	1.459	1.673	2.884
13...	1.880	1.841	1.932	1.902	1.655	1.814	3.542
14...	1.734	1.842	1.718	1.715	1.601	1.720	3.328
15...	1.636	1.559	1.581	1.435	Void	1.525	3.817
16...	1.933	1.855	1.792	1.954	1.878	1.868	3.851
17...	1.807	1.886	1.747	1.909	1.863	1.847	4.152
18...	1.912	1.856	1.701	1.857	1.751	1.787	4.244
19...	1.933	1.739	1.810	1.870	1.783	1.799	4.602
20...	1.877	1.783	1.790	1.694	1.755	1.756	5.060
21...	2.112	2.174	2.100	2.240	2.197	2.176	5.970
22...	1.996	2.103	1.908	1.878	2.018	1.980	5.233
23...	1.967	1.804	1.982	1.904	1.826	1.877	5.169
24...	2.091	2.150	2.132	2.309	2.377	2.240	6.446
25...	2.134	2.286	2.129	2.204	2.304	2.225	6.308
26...	2.098	2.425	2.386	2.366	2.361	2.385	7.649
27...	2.119	2.356	2.197	2.248	2.299	2.270	6.930
28...	2.130	2.980	2.661	2.746	2.858	2.805	7.961
29...	2.124	2.580	2.552	2.887	2.626	2.644	7.928
30...	2.076	2.615	2.375	2.590	2.437	2.496	8.139
31...	2.059	2.104	2.158	2.257	2.220	2.184	7.507
32...	1.621	1.542	1.501	1.569	1.468	1.519	5.976
33...	1.548	1.618	1.569	1.573	1.516	1.567	5.491
34...	1.676	1.687	1.723	1.650	1.555	1.652	4.912
35...	1.795	1.753	1.708	1.755	1.536	1.681	3.784
36...	1.766	1.703	1.838	1.693	1.562	1.689	3.327
37...	1.716	1.493	1.690	1.732	Void	1.626	3.554
38...	1.954	1.912	2.005	2.016	1.919	1.964	7.130
39...	1.795	1.655	1.579	1.555	1.522	1.578	5.513
40...	1.869	1.802	1.590	1.682	1.823	1.719	5.775
41...	1.804	1.714	1.775	1.618	1.829	1.735	5.616
42...	1.795	1.720	1.674	1.686	1.538	1.643	5.773
43...	1.987	1.942	1.909	1.952	1.863	1.914	7.120
44...	1.980	1.951	1.864	1.815	1.974	1.900	6.894
45...	1.926	1.855	1.873	1.835	1.856	1.854	5.710
46...	1.748	1.629	1.767	1.668	Void	1.684	5.469
47...	1.890	1.848	2.003	1.967	1.921	1.931	6.683
48...	1.768	1.600	1.445	1.522	1.431	1.495	5.509
49...	1.955	1.749	1.784	1.960	1.814	1.830	4.480
50...	1.693	1.522	1.645	1.434	1.422	1.510	5.658
51...	1.711	1.502	1.536	1.531	1.579	1.538	4.005
52...	1.816	1.831	1.806	1.820	1.608	1.749	6.222
53...	1.874	1.847	1.792	1.697	1.544	1.716	5.823
54...	1.737	1.693	1.747	1.775	1.644	1.710	5.012
55...	1.783	1.702	1.556	1.654	1.677	1.644	5.156
56...	1.731	1.836	1.658	1.664	1.698	1.702	4.565
57...	1.727	1.610	1.735	1.616	1.439	1.595	4.855
58...	1.685	1.623	Void	1.510	1.599	1.577	4.219
59...	1.764	1.708	1.446	1.688	1.604	1.605	4.143

TABLE V.—PER CENT DEVIATION OF MEASURED VALUES FROM CONTROL VALUES.

Box	Control Density, g per cu cm	Per Cent Deviation of Measured Density for Individual Tests				Group Deviation, per cent	Group Water Content, per cent
1	1.711	9.001	−7.013	2.688	−6.487	−0.351	3.053
2	1.767	−1.188	4.867	0.962	4.075	2.434	3.145
3	1.854	12.999	12.406	5.609	4.369	9.547	2.116
4	1.871	12.132	10.796	8.017	10.850	10.689	2.152
5	1.966	1.729	5.697	8.291	3.255	4.629	2.174
6	1.932	6.832	1.760	6.056	7.557	5.435	2.605
7	1.742	7.003	4.133	11.366	1.665	5.913	2.587
8	1.791	6.756	8.543	7.594	6.979	7.426	2.469
9	1.919	5.680	8.442	7.348	4.898	6.514	2.264
10	1.878	4.846	3.727	5.272	1.810	4.473	1.779
11	1.765	−10.141	2.266	2.663	−1.133	−1.530	2.565
12	1.690	3.964	1.302	5.385	−13.669	−1.006	2.884
13	1.880	−2.074	2.766	1.170	−11.968	−3.511	3.542
14	1.734	6.228	−0.923	−1.096	−7.670	−0.807	3.328
15	1.636	−4.707	−3.362	−12.286	Void	−6.785	3.817
16	1.933	−4.035	−7.294	1.086	−2.845	−3.363	3.851
17	1.807	4.372	−3.320	5.645	3.099	2.215	4.152
18	1.912	−2.929	−11.036	−2.876	−8.420	−6.538	4.244
19	1.933	10.036	−6.363	−3.259	−7.760	−6.932	4.602
20	1.877	−5.008	−4.635	−9.750	−6.500	−6.446	5.060
21	2.112	2.936	−0.568	1.326	4.025	3.030	5.970
22	1.996	5.361	−4.409	−5.912	1.102	−0.802	5.233
23	1.967	−8.287	0.763	−3.203	−7.168	−4.575	5.169
24	2.091	2.822	1.961	10.426	13.678	7.126	6.446
25	2.134	7.123	−0.234	3.280	7.066	4.264	6.308
26	2.098	15.586	13.727	12.774	12.536	13.680	7.649
27	2.119	11.184	3.681	6.088	8.494	7.126	6.930
28	2.130	39.906	24.930	28.920	34.178	31.690	7.961
29	2.124	21.469	20.151	35.923	23.635	24.482	7.928
30	2.076	25.963	14.403	24.759	17.389	20.231	8.139
31	2.059	2.186	4.808	9.616	7.819	6.071	7.507
32	1.621	−4.874	−7.403	−3.208	−9.439	−6.292	5.976
33	1.548	4.522	1.356	1.615	−2.067	1.227	5.491
34	1.676	0.656	2.804	−1.551	−7.220	−1.432	4.912
35	1.795	−2.340	−4.847	−2.228	−14.429	−6.351	3.748
36	1.766	−3.567	4.077	−4.134	−11.552	−4.360	3.327
37	1.716	−12.995	−1.515	0.932	Void	−5.245	3.554
38	1.954	−2.149	2.610	3.173	−1.791	0.512	7.130
39	1.795	−7.799	−12.809	−13.370	−15.209	−12.145	5.513
40	1.869	−3.585	−14.928	10.005	−2.461	−8.026	5.775
41	1.804	−4.989	−1.608	10.310	1.386	−3.825	5.616
42	1.795	−4.178	−6.740	−6.072	−14.317	−8.468	5.773
43	1.987	−2.265	−3.926	−1.761	−6.240	−3.674	7.120
44	1.980	−1.465	−5.859	−8.333	−0.303	−4.040	6.894
45	1.926	−3.686	−2.752	−4.725	−3.634	−3.738	5.710
46	1.748	−6.808	1.087	−4.577	Void	−3.661	5.469
47	1.890	−2.222	5.979	4.074	1.640	2.169	6.683
48	1.768	−9.502	−18.269	−13.914	−19.061	−15.441	5.509
49	1.955	−10.537	−8.746	0.256	−7.212	6.393	4.480
50	1.693	−12.200	−2.835	−15.298	−16.007	−10.809	5.658
51	1.711	−13.500	−10.228	−10.520	−7.715	−10.111	4.005
52	1.816	0.826	−0.551	0.220	−11.453	−3.689	6.222
53	1.874	−1.441	−4.376	−9.445	−17.609	−8.431	5.823
54	1.737	−2.533	0.576	2.188	−5.354	−1.554	5.012
55	1.783	−4.543	−12.731	−7.235	−5.945	−7.796	5.156
56	1.731	6.066	−4.217	−3.870	−1.906	−1.675	4.565
57	1.727	−6.775	0.463	−6.427	−16.676	−7.643	4.855
58	1.685	−3.680	Void	−10.386	−5.104	−6.409	4.219
59	1.764	−3.175	−18.027	−4.308	−9.070	−9.014	4.143

TABLE VI.—WATER CONTENTS OF SAMPLES TAKEN FOR DENSITY MEASUREMENTS.

Box	Control Density, g per cu cm	Water Contents for Individual Tests, per cent				Group Water Content, per cent
1	1.711	3.168	2.707	3.088	3.222	3.053
2	1.767	3.166	2.980	3.440	3.028	3.145
3	1.854	1.731	2.210	2.324	2.397	2.116
4	1.871	2.170	2.104	2.150	2.190	2.152
5	1.966	2.232	2.259	2.233	1.984	2.174
6	1.932	2.704	2.505	2.501	2.725	2.605
7	1.742	2.730	2.574	2.551	2.467	2.587
8	1.791	2.487	2.582	2.272	2.526	2.469
9	1.919	2.282	2.360	2.358	2.056	2.264
10	1.878	1.825	1.598	1.818	1.871	1.779
11	1.765	2.411	2.807	2.807	2.229	2.565
12	1.690	2.922	2.986	2.704	2.927	2.884
13	1.880	3.464	3.370	3.787	3.518	3.542
14	1.734	3.484	3.269	3.527	3.043	3.328
15	1.636	3.642	4.106	4.126	3.368	3.817
16	1.933	3.875	4.014	3.510	3.987	3.851
17	1.807	3.498	3.939	4.329	4.849	4.152
18	1.912	3.621	4.285	4.529	4.622	4.244
19	1.933	5.118	4.681	4.540	4.090	4.602
20	1.877	4.774	5.251	5.246	5.018	5.060
21	2.112	6.624	6.603	5.606	5.098	5.970
22	1.996	5.743	4.507	4.996	5.532	5.233
23	1.967	4.906	5.546	5.294	4.928	5.169
24	2.091	6.383	6.798	6.450	6.204	6.446
25	2.134	6.823	6.334	5.880	6.235	6.308
26	2.098	7.839	7.612	7.770	7.365	7.649
27	2.119	6.714	7.437	6.786	6.754	6.930
28	2.130	7.945	8.201	7.907	7.774	7.961
29	2.124	7.727	8.297	8.080	7.592	7.928
30	2.076	8.272	8.609	7.560	8.041	8.139
31	2.059	7.663	7.529	7.844	7.026	7.507
32	1.621	5.962	5.910	6.215	5.832	5.976
33	1.548	6.002	5.180	5.499	5.292	5.491
34	1.676	5.194	5.039	4.936	4.517	4.912
35	1.795	3.800	3.938	3.876	3.532	3.784
36	1.766	3.405	3.387	3.557	3.020	3.327
37	1.716	3.606	3.485	3.645	3.464	3.554
38	1.954	7.220	7.344	6.991	6.968	7.130
39	1.795	5.462	6.163	5.147	5.289	5.513
40	1.869	6.404	5.962	5.388	5.591	5.775
41	1.804	5.136	5.599	5.798	5.982	5.616
42	1.795	6.180	5.718	5.558	5.736	5.773
43	1.987	7.058	7.143	7.087	7.185	7.120
44	1.980	6.787	6.705	7.208	6.882	6.894
45	1.926	5.743	6.374	5.862	5.089	5.710
46	1.748	5.698	5.770	5.509	5.047	5.469
47	1.890	6.342	7.127	7.019	6.313	6.683
48	1.768	5.482	5.595	5.687	5.276	5.509
49	1.955	4.986	4.832	4.516	3.750	4.480
50	1.693	6.207	5.380	5.570	5.478	5.658
51	1.711	4.168	3.711	4.189	3.924	4.005
52	1.816	6.209	6.531	6.455	5.822	6.222
53	1.874	6.390	5.918	5.597	5.321	5.823
54	1.737	5.311	5.183	4.602	5.006	5.012
55	1.783	5.755	5.138	4.958	4.862	5.156
56	1.731	4.918	4.240	4.566	4.684	4.565
57	1.727	5.380	4.782	4.843	4.411	4.855
58	1.685	4.210	4.069	4.399	4.211	4.219
59	1.764	4.577	4.076	3.971	3.875	4.143

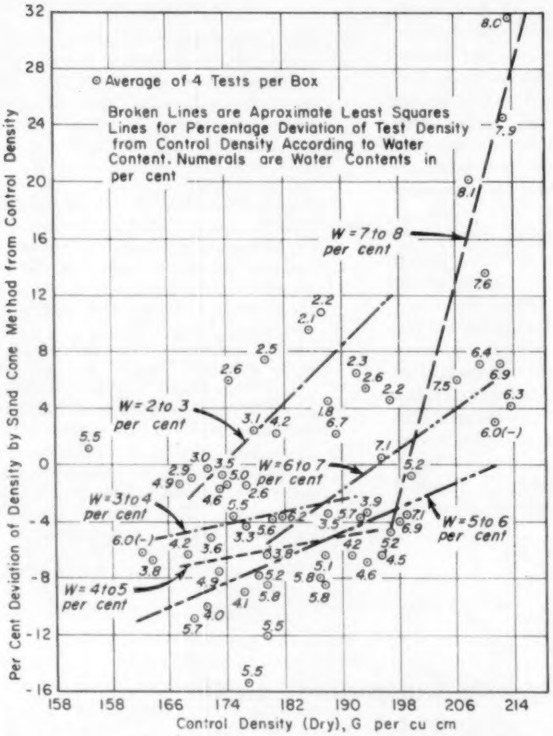

Fig. 7.—Trend lines according to water content of percentage deviation of densities measured by the sand cone apparatus *versus* control densities in Montalvo base course material.

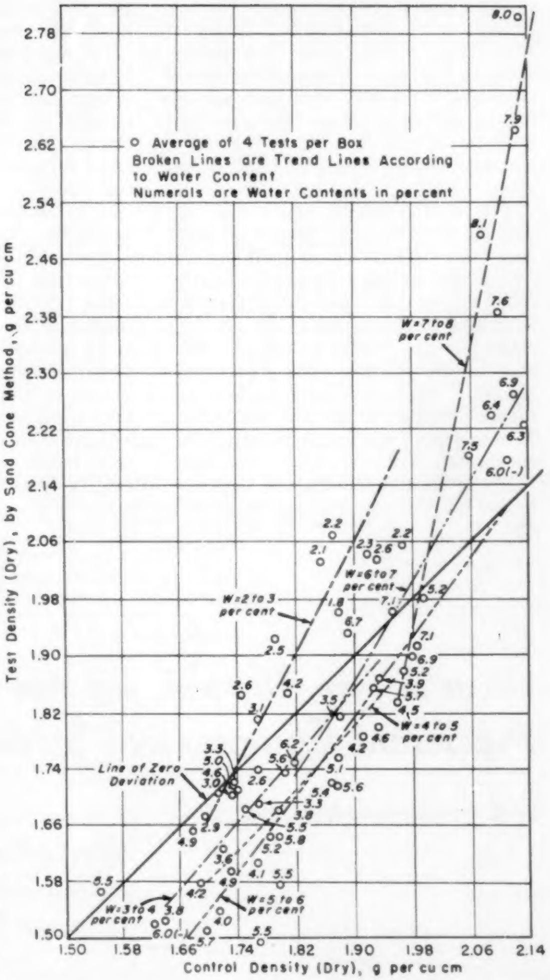

Fig. 8.—Trend lines according to water content of densities measured by the sand cone apparatus *versus* control densities in Montalvo base course material.

apparatus *versus* control densities. The author concluded that these trends should be straight lines determined on the basis of least squares. The trends are not sharply defined by the plotted data for each case. Actually the trends are much more pronounced and defined in Fig. 8, showing trend lines according to water content of density measured by the sand cone apparatus *versus* control densities.

The least-squares lines of Fig. 7 plot as slightly curved lines concave upward on Fig. 8. In each figure the trend lines appear to fit the data better than, for example, assuming straight-line relationships of data plotted in Fig. 8. If straight lines were to be assumed in the latter case, the corresponding trends would be lines curved concave downward in Fig. 7, and the terminal curvilinear directions would be contradictory to the over-all directional trends.

The over-all trend of the data in either Figs. 7 or 8 is somewhat unique and surprising to say the least. In Fig. 7, for example, the trends indicate an algebraic increase in per cent error of measured density with an increase in the control density. This trend is quite the opposite to that exhibited by cohesionless sand which showed an algebraic decrease in per cent error of measured density *versus* increasing control densities (1). Moreover, the changes in slope of the trend lines for different water contents are quite pronounced, and so are their changes in positions one from the other. It is regrettable that trend lines for water contents of less than 2 per cent could not be obtained. At such low water contents excessive dust was generated in handling the material and the resultant loss of fines would have been too great to assure the feasibility of the operation.

The author is at a loss to offer a highly scientific explanation for the observed phenomena. The dearth of similar data for various types of soil provides an inadequate basis for explanations. Perhaps the reason for the departure in behavior of the Montalvo base course material from that of sands is twofold. The interlocking of large stones probably altered the sensitivity of the mass to changes in volume caused by the type of shear required for sampling, compared to that of sands. The cohesiveness of the smaller particles in the base-course material may be an even more significant reason for its interesting pattern of behavior compared to that of sand.

The degree of cohesiveness of the finer particles was dramatically emphasized during the testing program. After 49 boxes of base course material at varying water contents had been tested, the succeeding 5 boxes failed to give satisfactory measured data. Because of the small amount of fine particles present in these boxes, the jug of the sand cone apparatus completely emptied of sand during volumetric measurements of the cavities. This sand filtered through the now larger voids of the base course material to the bottom of the box. It was then discovered that nearly all of the finer particles were adhering to the inside of the mixing drum. Two men working alternately inside the mixer for

nearly a day picked the material loose, amounting to about 6 cu ft. The fines were then remixed with the coarse particles but after 10 additional boxes were tested, the fines were again adhering to the inside of the mixer. This build-up of fines occurred very rapidly at water contents between 4 and 5 per cent.

The cohesive quality of the material was not observed during some preliminary tests using the same type of base course material but having a slightly different grading and in retrospect appearing to be less cohesive. For the relatively few tests performed with this similar material, the pattern of behavior was comparable to that of sands. Because of the few number of tests this trend was not considered to be conclusive; however, even this dim light of knowledge suggests that cohesion may be the primary reason for the pattern of behavior of the Montalvo base course material tested.

Certainly more data for varying soil types are needed to disclose fully the law of behavior of soils as they are sampled for density. It may be concluded that Montalvo base-course material is significantly sensitive to shearing effects of sampling for in-place density measurements. The degree of sensitivity depends upon the water content; however, it remains to be determined whether or not the water content during compaction or the water content at the time of sampling is the factor controlling the degree of sensitivity. There was no measurable change in water content between the time of compacting and time of sampling for density. The widths of the deviation bands are significantly large, ranging from a minimum of about 9 per cent to a maximum of about 15 per cent.

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(2) John R. Keeton, "A Study of Methods for Determining In-Situ Densities of Cohesionless Beach Soils," A Thesis presented to the Faculty of the Graduate School, University of Southern California, June, 1955.

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Effects of Type, Thickness, and Age of Capping Compounds on the Apparent Compressive Strength of Brick*

By N. W. KELCH and F. E. EMME

Actual differences in the apparent compressive strength of clay brick or structural clay tile are insignificant whether gypsum or sulfur-filler compound is used for capping the specimens.

The investigations reported in this paper were made pursuant to discussions and recommendations made by several members of ASTM Committee C-15 on Manufactured Masonry Units and by several members of its Subcommittee II on Clay Brick and Structural Clay Tile relating to the use of sulfur in lieu of gypsum for capping specimens of brick or tile to be tested for compressive strength.

The purpose of the tests was to compare the effect of variations in thickness and age of cappings on the apparent compressive strengths of high-strength brick and of low-strength brick and structural clay tile of nominally constant physical properties in each group. Two types of gypsum and two types of sulfur-filler compound were used for capping the units.

In ASTM Methods of Sampling and Testing Brick (C 67 – 50)[1] the capping material is specified: " . . . a thin coat of a neat paste of calcined gypsum (plaster of Paris) . . . . "

In ASTM Methods of Sampling and Testing Concrete Masonry Units (C 140 – 56)[2] provision is made for sulfur capping which reads in part: *(b) Sulfur-Filler Capping.*—A mixture of 40 to 60 per cent sulfur (by weight), the remainder being ground fire clay or other suitable inert material passing a No. 100 (149 micron) sieve, with or without a plasticizer, shall be used. . . ."

These two basic types of capping materials were used in the tests reported here.

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NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

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[1] 1955 Book of ASTM Standards, Part 3, p. 458.

[2] 1955 Book of ASTM Standards, Part 3, p. 511.

Materials and Procedures

One series of tests was made using high-strength facing brick, 2.187 by 3.5 by 7.5 in. in size, made from subsurface Alberhill, California, clay, stiff mud process, de-aired, side-cut, no coring, fired in a tunnel kiln.

A parallel series of tests was made using low-strength building brick, 3.25 by 3.25 by 10 in. in size, made from subsurface East Los Angeles clay, stiff mud process, de-aired, side-cut, no coring, fired in a field kiln.

A limited series of tests was carried out on building brick, 2.5 by 3.875 by 8.25 in. in size, made from South Los Angeles subsurface clay, stiff mud process, de-aired, side-cut, no coring, fired in a tunnel kiln. Similar tests were also made on structural clay facing tile made from Lincoln, California, clay, fired in a tunnel kiln, tested with cells vertically.

All bricks were sawed in half bisecting their length and each half identified in pairs; one half was capped with gypsum and the other half with sulfur.

In each individual test, five specimens were dried to constant weight and the two bearing surfaces of all specimens capped with gypsum were given a coat of shellac which was allowed to dry before capping. After capping, all such specimens were placed on their edges with capped faces separated and exposed to the air in a dry place in the laboratory.

The gypsum identified as GA was a commercial gypsum casting plaster which had a setting time of 20 min and which required 52.6 per cent (by weight) water.

The gypsum identified as GP was a proprietary gypsum marketed under a trade name which had a setting time of 20 to 30 min and which required 30.0 per cent (by weight) water.

The sulfur identified as SA was compounded in the Osborne Laboratories and consisted of 51.5 per cent sulfur with 48.5 per cent silica (pulverized burned brick), by weight.

The sulfur identified as SP was a proprietary sulfur-filler compound marketed under a trade name.

In one series, the specimens were held at a point to provide a capping $\frac{1}{8}$ in. thickness at the thinnest point. In a parallel series the cappings were made as thin as possible.

The thin cappings of gypsum were what may be termed paper-thin, but the thin cappings of sulfur were about

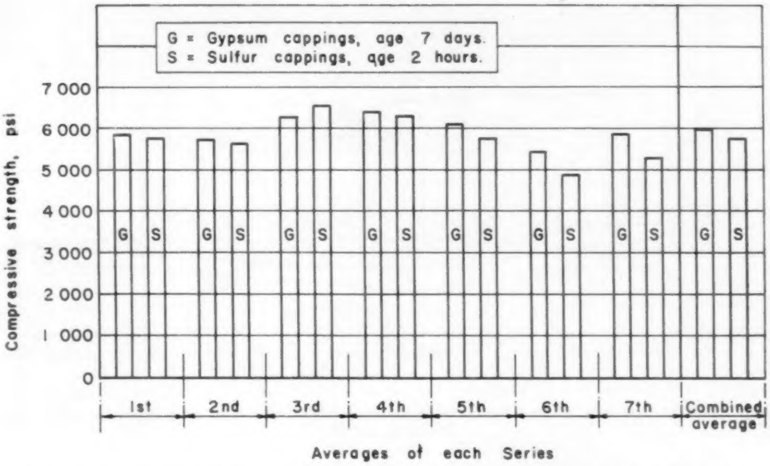

Fig. 1.—Comparison of gypsum *versus* sulfur cappings on building brick, 1954 series.

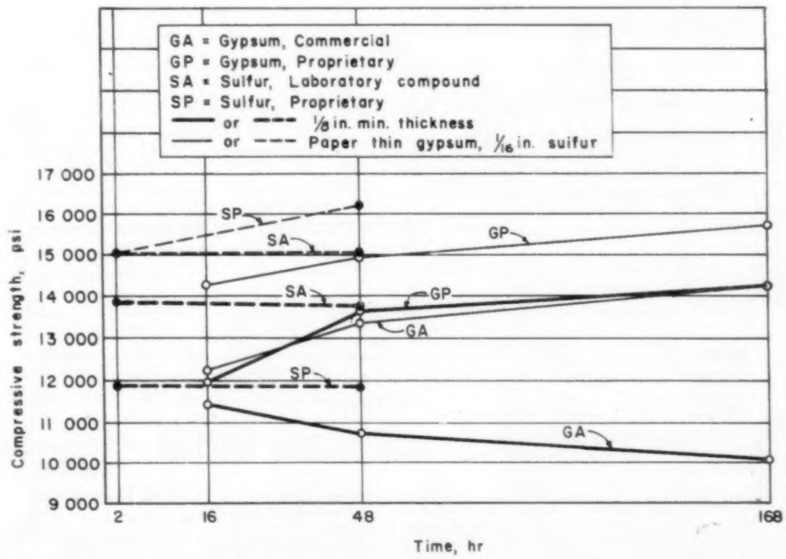

Fig. 2.—Comparisons of two types of gypsum *versus* two types of sulfur cappings on facing brick.

$\frac{1}{16}$ in. in thickness due to the rapid stiffening of the sulfur when the specimens were placed in it. All the thin cappings were made as thin as hand pressure of the operator could produce.

In the main series, the gypsum-capped specimens were tested at the ages of 16, 48, and 168-hr, and the sulfur-capped specimens were tested at the ages of 2 and 48-hr. In the limited final series which included building brick and structural clay tile, the gypsum-capped specimens were tested at the ages of 2, 5, 16, and 48-hr, and those with sulfur at the age of 2 hr. Testing procedures were those specified in ASTM Methods C 67[1] and C 112.[3]

Three 2-in. cubes of each of the four capping materials were made and tested at the same ages as the capped specimens.

Test Results

The authors feel that the results of the tests may be more readily evaluated in graph than in tabulated form; hence the latter have been omitted except for the limited final series to show the typical deviations from the averages.

Figure 1 shows results of previous tests made in 1954 on solid building brick using capping compounds similar to gypsum GA and to sulfur SA and the caps were at least $\frac{1}{8}$ in. thick at the thinnest point.

Figure 1.—The capping compounds were similar to gypsum GA and to sul-

[3] Methods of Sampling and Testing Structural Clay Tile (C 112 – 52), 1955 Book of ASTM Standards, Part 3, p. 495.

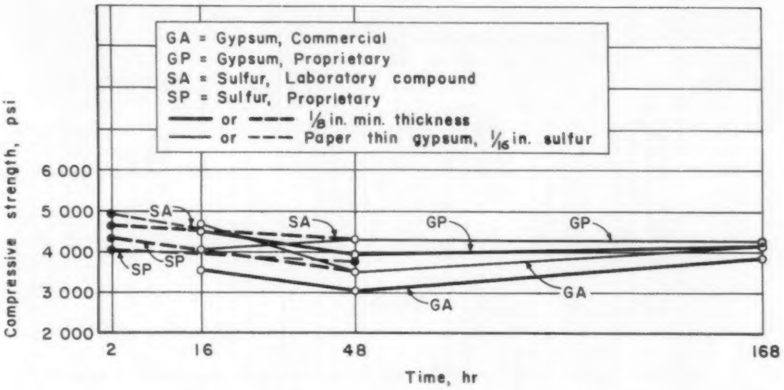

Fig. 3.—Comparisons of two types of gypsum *versus* two types of sulfur cappings on building brick.

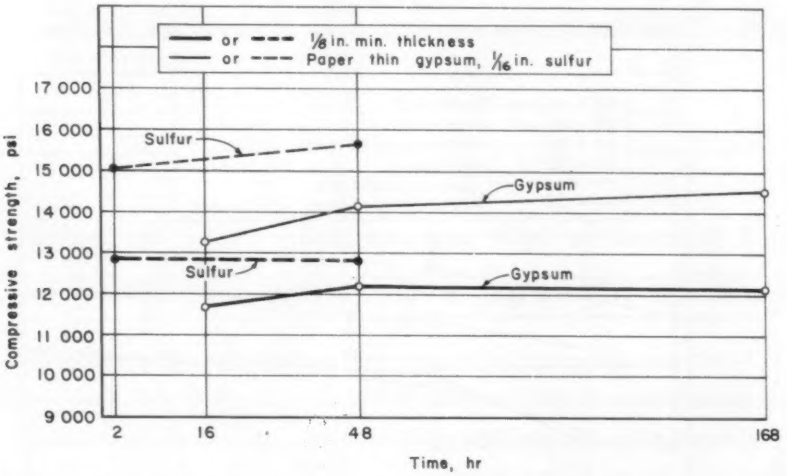

Fig. 4.—Comparisons of combined averages of two types of gypsum *versus* the combined averages of two types of sulfur cappings on facing brick.

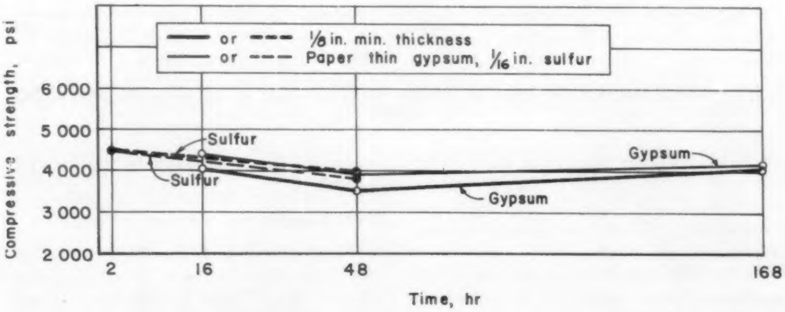

Fig. 5.—Comparisons of combined averages of two types of gypsum *versus* the combined averages of two types of sulfur cappings on building brick.

fur SA and the caps were at least $\frac{1}{8}$ in. thick at the thinnest point. The gypsum-capped specimens were aged seven days and the sulfur-capped specimens were aged 2 hr before testing. In only one series did the sulfur-capped specimens show a higher compressive strength than the gypsum-capped specimens, the values being 6274 psi with gypsum capping and 6574 psi with sulfur capping.

Figure 2 shows the results obtained using relatively high-strength facing brick. The thin-capped specimens show higher values than those capped with thick caps in each of the groups for both gypsum and sulfur caps. Some increase is shown in strength due to aging in most of the groups.

Figure 3 shows the results obtained using relatively low-strength building brick. The results are more erratic than those shown in Fig. 2, due, it is presumed, to the variations in the structure of individual bricks as well as in the two halves of the same brick.

Figure 4 shows the over-all average results for the tests on facing brick. The maximum value for thin gypsum cappings was 14.531 psi, and for thin sulfur cappings these values were 15,641 psi.

Figure 5 is similar to Fig. 4 except that the tests were made on the relatively low-strength building brick. The maximum value for thin gypsum cappings was 4393 psi, and the maximum value for thin sulfur cappings was 4522 psi.

Figure 6 shows the results of compression tests on 2-in. cubes of the two types of gypsum and of the two types of sulfur compounds. The differences in these results are noteworthy since all four materials comply with ASTM specifications C 67 and C 140.

Figure 7 shows the results of the limited and final series of compression tests on building brick and on structural clay tile using GP gypsum and using SP sulfur for thin cappings.

TABLE I.—COMPRESSIVE STRENGTHS OF GYPSUM *versus* SULFUR CAPPINGS ON BUILDING BRICK, psi.

GP Gypsum				SP Sulfur
2 hr	5 hr	16hr	48 hr	2 hr
5880.......	6763	6283	6194	6532
5856.......	6573	5925	6629	6381
6842.......	7053	6456	7317	6532
6841.......	6008	6218	7470	6667
5943.......	6546	6623	5370	6809
Av. 6200.......	6589	6301	6596	6584

TABLE II.—COMPRESSIVE STRENGTHS OF GYPSUM *versus* SULFUR CAPPINGS ON STRUCTURAL CLAY TILE (GROSS AREA), psi.

GP Gypsum				SP Sulfur
2 hr	5 hr	16 hr	48 hr	2 hr
8 131.....	7269	7 644	10 487	8544
7 624.....	8439	9 542	9 522	8323
9 717.....	8839	10 748	8 732	8356
10 365.....	8000	11 540	10 489	8480
8 513.....	8041	11 006	10 176	8593
Av. 8870.....	8118	10 096	9 953	8459

Tables I and II show the deviation from the averages exhibited in Fig. 7, which are typical of the deviations from the averages of all tests reported here.

Behavior of the Two Types of Sulfur

In testing the 2-in. cubes, it was observed that the GP sulfur showed definite lateral deformation under load. After failure, this type of sulfur adhered tightly to the head and lower steel plate of the testing machine. Where GP sulfur was used for capping the high-strength facing brick and also the tile and the building brick in the limited final series, this same adhesion occurred after testing.

In the tests which paralleled those mentioned in the preceding paragraph where GA sulfur was used, no such deformation or adhesion occurred.

In melting both types of sulfur, extreme care was exercised to avoid overheating.

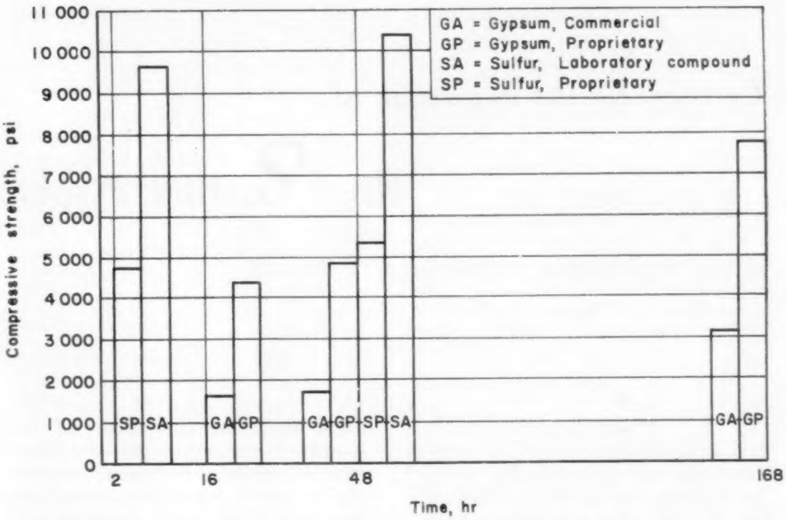

Fig. 6.—Comparisons of tests on 2-in. cubes of two types of gypsum *versus* two types of sulfur.

Summary

The three grades of brick and the one grade of tile capped with two types of gypsum and two types of sulfur showed variations in apparent compressive strength due to type of capping material used, thickness of capping material, and to the age of the capping at time of testing.

Generally the GP proprietary gypsum gave higher results than the GA commercial gypsum casting plaster. Similarly, the SA laboratory sulfur-filler compound gave higher results than the SP proprietary sulfur compound.

Generally the thin cappings produced higher results than thick cappings.

Strength increased with age in the compressive tests on the cubes of all four types of capping materials. However, the tests on the units showed some variations with age.

Conclusions

The data developed from the tests reported herein appear to warrant the following conclusions:

1. Brick and structural clay tile units capped with one type of gypsum may be expected to show higher apparent compressive strengths than similar units capped with one type of sulfur-filler compound.

2. Thin cappings may be expected to produce higher results than thick cappings.

3. The psi variations in apparent compressive strength of units of similar grade capped with either gypsum or sulfur may be expected to be of small magnitude.

4. The only advantage in using a sulfur compound instead of gypsum for capping building brick or structural clay tile prior to a test for compressive strength is that it requires less time to harden sufficiently before a test is made.

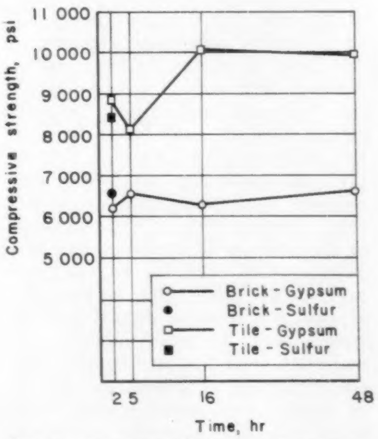

Fig. 7.—Averages of results of compressive tests made on building brick and structual clay tile showing comparisons using gypsum *versus* sulfur for capping the specimens.

Mass Spectrometry Explained

THE outstanding advantage of mass spectrometry is its ability to analyze gases and liquids more rapidly than other methods. Analyses which formerly took days can now be completed in minutes by the use of automatic mass spectrometry and computation. Included among the mass spectrometer's many uses are refinery stream analyses, chemical reaction process monitoring, chemical and physical research, medical isotope studies, metallurgy reduction, absorption techniques, and engine combustion analyses.

The commercial mass spectrometer suitable for analytical applications was developed by Consolidated Electrodynamics Corp. of Pasadena, Calif., when the firm became interested in a mass spectrometer capable of analyzing the complex hydrocarbon mixtures encountered in the petroleum industry.

A mass spectrometer developed at California Institute of Technology was loaned to Consolidated to facilitate preliminary work. After about four years of research by Harold W. Washburn and his coworkers, a commercial instrument was placed on the market by Consolidated. The first one was delivered to Atlantic Refining Co. in late 1942.

The mass spectrometer's operation is based on the fact that every molecule has a unique construction pattern, its

Continued on page 68

Criterion for the Evaluation of

Roof Coating Asphalts

By C. E. WILKINSON, L. STRIKER, and R. N. TRAXLER

Considerable effort has been expended over a period of years to develop a rapid and satisfactory method for evaluating the suitability and service life of roof coating asphalts. An attempt was made, in the initial stage of this investigation, to develop an accelerated weathering test procedure which would serve this purpose. Many different cycles, comprising exposure of thin films of asphalt to water spray, freezing, thawing, and a source of actinic light, with and without the presence of moisture, were tried. In addition to the long time required, none of the test results gave satisfactory correlations with atmospheric weathering data. Consequently, a new approach to the problem of durability was projected, which involved an extensive study of the relationship between the physical and chemical properties of an asphalt and its weatherability. It was found from this investigation that a selected group of physical and chemical tests shows reasonably good correlation with the durability of asphalt under atmospheric service conditions.

The purpose of this paper is to present a criterion for the rapid evaluation of the serviceability of roof coating asphalts and their suitability for the manufacture of asphalt prepared roofing.

Experimental Work

In the original work on this investigation more than 20 physical and chemical test procedures were employed. Some of the tests did not help in evaluating the suitability of the asphalt for roof coating, or were found to be of no value in making correlations with atmospheric weathering and were therefore eliminated. In some instances two or more procedures showed the same trends relative to weatherability. Only one test from each of such groups was selected for evaluation purposes. Four tests were found to have no direct bearing on the durability of roof coating asphalts but were included because they are required for specifying an asphalt having the proper consistency, temperature susceptibility, and suitability for the manufacture of prepared roofing. From the original list of test procedures employed, ten were selected as applicable to rapid evaluation of roof coating asphalts, and are tabulated below. The four tests having no direct relationship with durability are listed first and the six that correlate directly with durability follow.

Methods of Test for:
- Softening Point of Bituminous Materials (Ring-and-Ball Method) (ASTM D 36 – 26),[1]
- Penetration of Bituminous Materials (ASTM D 5 – 52)[1] at 32 F,
- Penetration of Bituminous Materials (ASTM D 5 – 52)[1] at 115 F, and
- Flash and Fire Points by Cleveland Open Cup (ASTM D 92 – 56).[2]

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R. N. TRAXLER, research supervisor, Texaco Port Arthur-Port Neches Research Laboratories, has devoted the past 30 years to research on asphalt. His work has involved the development and improvement of roofings, road building and specialty asphalts, asphalt emulsions, and protective coatings. Fundamental investigations have included studies on the rheological properties and composition of asphalts.

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[1] 1955 Book of ASTM Standards, Part 3.

Methods of Test for:
Specific Gravity of Asphalts and Tar Pitches Sufficiently Solid to be Handled in Fragments (ASTM D 71 - 52),[1]
Penetration of Bituminous Materials (at 77 F) (ASTM D 5 - 52),[1]
Insoluble in *n*-Pentane, per cent (AASHO T 46 - 35),[3] and
Tentative Method of Test for:
Contact Compatibility Between Asphaltic Materials (Oliensis Test) (ASTM D 1370 - 55 T),[1] and methods for
Cyclics, per cent, and
Oxidation-Hardening Index.

Fifteen samples from different sources, including airblown as well as mixed and blown asphalts, were subjected to the above tests. Data, including atmospheric weathering results for correlation purposes, are given in Table I. Atmospheric weathering data were obtained under Gulf Coast conditions in the following manner:

A film of asphalt 0.025 in. thick was applied to an aluminum panel which was exposed facing south at an angle of 30 deg. The film of asphalt was considered to have failed when a crack to the metal panel was visible. Duplicate panels were exposed for each asphalt and average values to the nearest five weeks are reported. Obviously, the results are reproducible only within a few weeks and the weathering data shown in Table I should not be taken as exact or absolute values.

Significance of the Specification Tests

Each of the ten tests selected and reasons for its inclusion in the criterion and limits established are discussed briefly hereafter:

Softening Point

There is no direct relationship between softening point and durability *per se*. However, the softening point test in conjunction with the penetration tests is considered necessary for manufacturing control and in selecting roof coating asphalts having the desired temperature-susceptibility characteristics. A range of 210 to 230 F Ring-and-Ball appears to be satisfactory for this purpose.

Penetration at 32 F

The penetration at 32 F also does not show a direct correlation with durability, but in order to eliminate brittle products which would shatter when subjected to shock at low temperatures, the minimum value of 10 has been set for this test.

Penetration at 115 F

Again, the penetration at 115 F does not correlate directly with durability, but the maximum of 40 was selected to eliminate asphalts that might cause slippage when exposed to high temperature on roof decks. A minimum of 25 was established in order to insure proper temperature-susceptibility characteristics.

Flash Point

There is no correlation of the flash point test with the weatherability of coating asphalts. Yet, because of the high temperatures at which such asphalts are handled during the manufacture of prepared roofing a minimum flash of 500 F is necessary to eliminate the fire hazard.

Specific Gravity at 77 F

In general, coating asphalts having a specific gravity in the range of 0.990 to 1.040 possess good resistance to deterioration under service conditions.

Penetration at 77 F

Roof coating asphalts (210 to 230 F Ring-and-Ball) possess good durability under service conditions if the ASTM penetration at 77 F falls between 18 and 25. Within this penetration range better durability usually is associated with higher values.

Insoluble in n-Pentane

In general, low asphaltene content (40 per cent or less) appears to be associated with roof coating asphalts possessing good durability.

Compatibility

The compatibility test was made a part of the criterion to eliminate incompatible combinations of saturant and coating asphalts which are known to be unsatisfactory from the standpoint of weathering. Such combinations cause exudation blisters to break through to the surface of the roofing, forming oily spots which mar the appearance. The exudation blisters also allow moisture to enter the roofing. Although it is possible to find a saturant that is compatible with any desired coating, it may not be practical because of economic or other considerations. Thus, the compatibility test is considered important in the criterion to insure the selection of compatible combinations of coating and saturant asphalts for the production of quality roofing.

[2] 1956 Supplement to Book of ASTM Standards, Parts 3 and 5.
[3] Method of Test, Am. Soc. State Highway Officials.

TABLE I.—TEST DATA FOR HARD ASPHALTS FROM VARIOUS SOURCES.

	Specific Gravity at 77 F	Softening Point, deg Fahr	Penetration at			Flash Point, deg Fahr	Insoluble *n*-Pentane, per cent	Compatibility[a]	Cyclics, per cent	Oxidation Hardness Index	Atmospheric Weathering Weeks to Failure
			77 F	32 F	115 F						
Limits—Minimum	0.990	210	18	10	25	500	...	Must be	...	...	...
Maximum	1.040	230	25	..	40	...	40	...	12	10	...
Asphalt											
1	0.992	219	20	14	31	600	33.6	C	10.7	3.6	155+
2	0.990	222	21	16	34	590	36.4	C	10.7	6.1	155+
3	0.996	226	22	16	35	625	34.1	C	10.0	4.3	155
4	1.000	221	22	14	35	560	35.9	C	11.1	6.6	110
5	1.023	223	22	15	32	565	39.3	C	12.0	10.0	95
6	0.996	224	25	21	36	560	32.0	C	14.2	3.0	100
7	1.038	210	21	15	35	570	43.5	C	11.2	9.6	130
8	1.029	218	20	14	32	565	41.0	C	10.8	9.2	110
9	1.008	218	18	14	28	595	36.4	C	15.1	7.8	75
10	0.995	227	25	21	34	560	35.1	C	15.3	2.7	75
11	1.041	223	23	13	36	585	33.3	NC	12.9	8.1	75
12	1.016	224	19	12	34	585	37.5	NC	13.2	14.1	65
13	1.015	227	13	8	24	625	37.4	C	10.6	11.9	75
14	1.031	214	18	13	33	505	41.8	C	16.5	10.8	130
15	1.027	217	14	9	24	530	41.6	C	15.7	38.9	75

NOTE.—Underscored tests indicate failure to pass the requirements of the criterion. Some of these can be corrected by making adjustments in processing conditions.
[a] Each roof coating asphalt was tested for compatibility against several different saturants.

Cyclics, Per Cent

The term "cyclics" has been selected to designate that portion of the *n*-butanol-soluble fraction of an asphalt that is also soluble in acetone as determined by the method of component analysis.[4] Generally, those coating asphalts containing more than 12 per cent cyclics showed poor durability under service conditions.

Oxidation-Hardening Index

It is generally accepted that oxidation is one of the principal causes of deterioration of asphalts exposed to atmospheric weathering. Also, it has been found that different asphaltic residua, when air-blown under the same conditions of temperature and air rate, oxidize at different rates to yield asphalts of the same softening point. Laboratory investigations indicated that usually the residua which oxidized most rapidly produced coating asphalts having the lowest resistance to deterioration under service conditions. Thus, it may be assumed that *coating asphalts* having the highest affinity for oxygen are likely to deteriorate most rapidly when subjected to outdoor weathering.

An adaptation of a method proposed for evaluating the serviceability of paving asphalts,[5] which utilized data from an oxygen bomb test, was employed for obtaining oxygen absorption and hardening data on roof coating asphalts.

The modified procedure consists of subjecting a large surface area of asphalt to the action of oxygen at 100 psi at 176 F (maximum temperature expected in service), and recording the pressure drop over a period of 72 hr. To obtain the large surface area approximately 4 g of asphalt are weighed into each of six cadmium-plated $1\frac{1}{2}$ oz Gill type can lids and these are mounted in a cadmium plated rack for each bomb. Each asphalt is tested in duplicate. After 72 hr exposure to oxygen the asphalt is removed from the containers and recombined for a penetration test at 77 F.

The data obtained by the above procedure are used in calculating an "Oxidation-Hardening Index" which appears to be valuable, when used in conjunction with other tests, for predicting the serviceability of roof coating asphalts. The index is the ratio between two ratings and is expressed by the equation:

$$\text{Oxidation-Hardening Index} = \frac{\text{Oxidation rating}}{\text{Hardening rating}} \times 100$$

The Oxidation-Hardening Index expresses a combination of the oxygen absorption capacity of an asphalt, in amount and rate at a fixed time, together with the hardening caused by a given oxygen absorption. The Index is expressed in psi per hr.

The *oxidation rating* relates the oxygen consumption of an asphalt to time and is obtained by multiplying the oxygen pressure drop at 72 hr (the observed gage pressure at that time subtracted from the initial test pressure) by the rate of oxygen consumption (dP/dt) at the completion of the run. This rate is found by plotting the pressure drop against time and calculating the slope of the tangent to the curve at the completion point. The oxidation rating permits an over-all characterization of the oxygen absorption behavior of the asphalt, since it projects the oxidation beyond the period of the test's duration. This quantity is expressed by the unit psi sq per hr.

The *hardening rating* is the oxygen consumption (pressure drop, psi) necessary to lower the penetration at 77 F to a point where the asphalt loses its adhesive and cohesive properties and becomes brittle. For coating asphalts, this was assumed to be 10 penetration at 77 F.

Anderson[5] and his associates showed that the *hardening rating* for paving asphalts was derived from a linear relationship which existed between the pressure drop and the logarithm of the penetration. In the present work the penetration of the asphalt just prior to subjecting it to the oxidation test and the penetration of the oxidized asphalt are plotted on a log scale against pressure drop, and the pressure drop for 10 penetration obtained by extrapolation.

Most of the asphalts which showed good durability under service conditions had Oxidation-Hardening Indices below 10.

Use of Criterion for Evaluating Roof Coating Asphalts

The following criterion was used in making correlations with atmospheric weathering results for the 15 samples studied:

Test	*Limits*
Softening Point	210 to 230
Penetration at 32 F, 200 g, 60 sec	10 minimum
Penetration at 115 F, 50 g, 5 sec	25 to 40
Flash point	500 minimum
Specific gravity at 77 F	0.990 to 1.040
Penetration at 77 F, 100 g, 5 sec	18 to 25
Insoluble in *n*-pentane, per cent	40 maximum
Compatibility	Must be
Cyclics, per cent	12 maximum
Oxidation-Hardening Index	10 maximum

In making correlations of a series of tests with any other significant property of an asphalt, some arbitrary method of grading must be established. Naturally, when using the results of tests which are empirical a 100 per cent correlation is not likely when several samples are involved. Of the fifteen asphalts studied, those which passed all the requirements of the above criterion were classified as being of highest quality. They are listed in the upper portion of Table I. Those asphalts that failed one requirement of the criterion that could not be corrected by adjustments in the processing conditions were classified as satisfactory for roofing manufacture and are listed next. Asphalts which failed two or more of the requirements were considered of poor quality and are listed at the bottom of the table.

The results of atmospheric weathering were used in this evaluation because, in the final analysis, this is the only satisfactory procedure for making a correlation of a group of test results with the serviceability of an asphalt. An arbitrary value of 90 weeks to failure under atmospheric weathering was established as the dividing line between satisfactory and unsatisfactory asphalts. Of the 15 samples investigated, 9 were rated satisfactory for durability on the basis of atmospheric exposure. Only 1 of the 9 was listed among those that were rated *poor* on the basis of the criterion requirements. Of the 6 asphalts rated unsatisfactory on the basis of weathering two were listed among those classified *satisfactory* by the criterion. Therefore, a correlation between criterion requirements and actual atmospheric weathering was exhibited by 12, or 80 per cent, of the 15 samples evaluated.

By this method, a clue to the serviceability of roof coating asphalts can be ascertained within one week in the laboratory and their suitability for roofing manufacture can be established without waiting a long period of time for atmospheric weathering results.

[4] R. N. Traxler and H. E. Schweyer, "Measurement of Oxidation Stability of Road Asphalts," *Oil and Gas Journal*, Vol. 52, p. 158 (1953).

[5] A. P. Anderson, F. H. Stross, and A. Ellings, "How to Make Component Analysis," *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 14, p. 45 (1942).

Nitric-Hydrofluoric Acid Evaluation Test for Type 316L Stainless Steel

By DONALD WARREN

Research has shown that the 10 per cent nitric – 3 per cent hydrofluoric acid test can be successfully used to evaluate the intergranular corrosion resistance of type 316L stainless steel. Such a test is sensitive to damaging carbide precipitation in the grain boundaries of the steel but is insensitive to the presence of sigma phase. The optimum test conditions consist of two 2-hr periods in a 10 per cent nitric – 3 per cent hydrofluoric acid solution at 70C.

PREVIOUS research has shown the need for a quantitative test which can detect damaging carbide precipitation in the grain boundaries of stainless steel when sigma phase is also present. The intergranular corrosion resistance of most austenitic stainless steels, such as types 304, 304L, and 316, can be adequately evaluated by means of the standard nitric acid test.[1] However, the nitric acid test is generally not applied to type 316L stainless steel, because this test is sensitive to the presence of sigma phase in the steel (**1,2**).[2,3]

Sigma phase is formed in type 316L stainless steel under essentially the same conditions that cause carbide precipitation (**1,3**).[3] For example, when type 316L stainless steel is given a sensitizing treatment[4] of 1 hr at 1250 F, water quench (WQ), sigma phase can be precipitated at the grain boundaries of the steel along with chromium carbides. Prior research showed that 40 out of 80 commercial heats of type 316L stainless steel failed the standard nitric acid test after a heat-treatment of 1 hr at 1250 F, WQ.[3] These failures were primarily due to grain-boundary sigma phase formed during the sensitizing heat treatment. In contrast, the available evidence indicates that sigma phase does not adversely affect the intergranular corrosion resistance of type 316L stainless steel in corrosive media other than hot nitric acid solutions, whereas carbide precipitation can cause severe intergranular corrosion (**4**).[5] Corrosion tests have been made on types 316 and 316L stainless steel in hot acetic, citric, lactic, oxalic, phosphoric, and sulfuric acid solutions.[5] Results of these tests showed that serious intergranular attack occurred when carbides were present in the grain boundaries but not when sigma phase was similarly located and carbides were absent.[5]

The above results pointed up the need for a corrosion test which could be reliably used to evaluate type 316L stainless steel for any chemical plant application not involving hot nitric acid service. Such a test should be sensitive to damaging carbide precipitation and insensitive to sigma phase. Other investigations (**1,2,5,6**) revealed at least two intergranular corrosion tests meeting these requirements: (1) the acidified copper sulfate test, and (2) the nitric-hydrofluoric acid test. Of the two, the nitric-hydrofluoric acid test appeared to offer the best potential as an evaluation test for type 316L stainless steel. It is quite sensitive to very small amounts of carbide precipitation (**7**) and requires only very short test times, 1 to 4 hr. The acidified copper sulfate test was rejected as a possible routine evaluation test, because: (*a*) long test times (1000 hr or more) are required to develop maximum sensitivity to carbide precipitation, (*b*) the electrical resistance measurements required for quantitative evaluation are costly and time-consuming, and (*c*) there are limitations on the dimensions of the specimen that can be used.

The principal disadvantages of the 10 per cent nitric – 3 per cent hydrofluoric acid test are: (*a*) a high rate of general corrosion which varies widely with differences in alloy composition, and (*b*) the care and specialized equipment required for handling the highly corrosive acid. While the nitric-hydrofluoric acid test had never been quan-

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[1] Tentative Recommended Practice for Boiling Nitric Acid Test for Corrosion-Resisting Steels (A 262 – 55 T), 1955 Book of ASTM Standards, Part 1, pp. 1108–1118.

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

[3] D. Warren, Unpublished research, "The Constitution and Nitric Acid Corrosion Resistance of Type 316L Stainless Steel."

[4] Type 316L stainless steel is intended for use in the as-welded condition. A sensitizing treatment of 1 hr at 1250 F, water quenched (WQ), is used to determine the resistance of the steel to carbide precipitation upon welding. The procedure is the same as that for other stainless steels (types 304L and 347) intended for use in the as-welded condition.

[5] D. Warren, "The Effect of Sigma Phase *versus* Chromium Carbides on the Intergranular Corrosion of Types 316 and 316L Stainless Steel," Presented at the National Assn. of Corrosion Engineers Annual Meeting in San Francisco, March 19, 1958.

titatively applied, unpublished research[6] indicated that this was possible. For example, effect of variations in the general corrosion rate can be minimized by using the ratio of the sensitized corrosion rate to the annealed corrosion rate instead of the absolute corrosion rate.

History of the Nitric-Hydrofluoric Acid Test

The origin of the nitric-hydrofluoric acid test is not at all clear. As far as can be determined, Becket and Franks (**8**) and Payson (**9**) were the first to report the use of a nitric-hydrofluoric acid solution for testing stainless steel. These investigators used the mixed acid solution to reveal carbide precipitation in the heat-affected zones of welded samples of austenitic stainless steel.

According to Franks,[7] in 1929 it was found at their laboratories, and at others, that a solution containing 1 to 3 per cent hydrofluoric acid and about 10 per cent nitric acid heated to 70 C descaled the annealed 18 chromium, 8 nickel stainless steels quite satisfactorily. In a series of pickling experiments, this solution was used to descale laboratory specimens of stainless steel which had been sensitized prior to testing in an acidified copper sulfate solution. The sensitized samples completely disintegrated after a very short time due to intergranular attack by the nitric-hydrofluoric acid pickling solution. Because of its high sensitivity to precipitated carbides, the nitric-hydrofluoric acid solution was then used on welded samples to determine whether the heat-affected zones were subject to intergranular corrosion.

Later investigators (**1,2,5,10–14**) have employed solutions varying in concentration from 10 to 15 per cent nitric and 2 to 4 per cent hydrofluoric acid at temperatures ranging from 60 C to boiling (see Table I). However, at the time of the ASTM Symposium on Evaluation Tests for Stainless Steel,[8] use of a 10 per cent nitric - 3 per cent hydrofluoric acid solution at 70 to 80 C seemed to have become fairly standard practice.

In most cases, specimens subjected to the nitric-hydrofluoric acid test were evaluated by appearance and weight loss. Only one investigator (**14**) used electrical resistance measurements in conjunction with this test. A nitric-hydrofluoric acid mixture is more potent than any other test solution in revealing susceptibility to weld decay (intergranular attack on the heat-affected zones of welded stainless steel) (**7**). Despite its potency, the nitric-hydrofluoric acid test has never been used on a quantitative basis for evaluation of stainless steel, principally because it produces severe general corrosion on annealed material. The high general corrosion rates tend to obscure the weight losses caused by intergranular attack, and this makes quantitative evaluation by weight-loss measurements difficult.

Approach Used in Current Study

The current investigation can be logically divided into two phases. The first phase dealt with the development of an optimum procedure for testing types 316 and 316L stainless steel in a 10 per cent nitric - 3 per cent hydrofluoric acid solution. The second phase was concerned with using this test procedure to evaluate the intergranular corrosion resistance of 80 commercial heats of types 316 and 316L stainless steel. In the latter phase, the electrolytic oxalic acid etching test[9] was used to evaluate the steel prior to applying the nitric-hydrofluoric acid test.

EXPERIMENTAL DETAILS

Type and Source of Steels

Only two types of austenitic stainless steels were included in this study: type 316 (0.08 per cent max carbon) and type 316L (0.03 per cent max carbon). Since the nitric-hydrofluoric acid test was being developed as an evaluation test for type 316L, the greatest number (62) of the 80 heats evaluated were of this type. Eighteen heats of type 316 stainless steel were tested to show the effect of carbon contents greater than 0.03 per cent on the behavior of sensitized material in the nitric-hydrofluoric acid solution.

Table II gives the chemical composition of the 80 heats tested. All of these heats were commercially produced. A majority of the heats were available as laboratory stock; the others were obtained as samples submitted to du Pont for corrosion evaluation.

[6] M. A. Streicher, private communication.
[7] R. Franks, private communication.
[8] Issued as separate publication ASTM *STP No. 93* (1950).
[9] Tentative Recommended Practice for Boiling Nitric Acid Test for Corrosion-Resisting Steels (A 262 – 55 T), 1955 Book of ASTM Standards, Part 1, pp. 1112–1118.

TABLE I.—NITRIC-HYDROFLUORIC ACID SOLUTIONS USED BY OTHER INVESTIGATORS TO EVALUATE THE RESISTANCE OF AUSTENITIC STAINLESS STEELS TO INTERGRANULAR CORROSION.

Test Conditions				Method Used to Evaluate Intergranular Attack				Remarks	References
Test Solution		Test Temperature, deg Cent	Length of Test						
Nitric Acid, per cent	Hydrofluoric Acid, per cent			Appearance	Weight Loss	Micro. Examination	Electrical Resistance		
10.......	2	60	Forty-eight ½-hr periods	X	..	..	..	Welded samples only	(**10**)
10.......	3	70	Five 1-hr periods	X	X	..	..	...	(**1,11**)
		73	Four ½-hr periods	X	X	..	..	...	(**5**)
		80	Three 4-hr periods	X	X		..	...	(**2,12**)
10.......	4	60	Four ½-hr periods	X	..	..	..	Welded samples only	(**13**)
15.......	3	Hot	One 2-hr period	X	X	X	X	...	(**14**)
		Boiling	Two 4-hr periods	X	..	..	..	Welded samples only	(**13**)
[a]	[a]	[a]	One 2-hr period	X	..	..	..	First recorded use of test, welded samples only	(**8,9**)

[a] The concentration of the nitric-hydrofluoric acid solution and the test temperature were not given.

TABLE II.—CHEMICAL COMPOSITION OF 80 COMMERCIAL HEATS OF TYPES 316 AND 316L STAINLESS STEEL.

Heat Number[a]	Form and Size	Chemical Composition, per cent								
		Carbon[b]	Chromium	Nickel	Molybdenum	Manganese	Silicon	Phosphorus	Sulfur	Nitrogen
BZ7-596	Forging	0.042	17.73	12.95	2.18	1.96	0.72	0.019	0.014	...
CX9-451	3 ¾ in. round	0.024	18.16	13.59	2.35	1.65	0.69	0.022	0.012	...
CX9-453	4 in. round	0.045	17.98	12.85	2.19	1.93	0.57	0.021	0.017	...
CX9-455	1 ¾ in. round	0.050	17.59	12.76	2.14	1.86	0.63	0.020	0.029	...
CX9-457	Forging	0.028	17.51	13.82	2.45	1.91	0.54	0.020	0.018	...
D-61	½-in. plate	0.031	17.41	12.45	2.30	1.83	0.48	...	...	...
D-63	⅛-in. sheet	0.031	17.41	12.45	2.30	1.83	0.48	...	...	...
DS5	¼-in. plate	0.055	17.45	13.50	2.01	1.96	...	...	...	...
DY4-135	½-in. plate	0.041	17.38	13.53	2.22	1.92	0.48	0.023	0.015	...
EI6	⅛-in. sheet	0.022	17.86	13.11	2.41	2.16	0.57	...	...	0.013
EM6	½-in. plate	0.033	17.93	13.51	2.47	1.77	0.31	0.023	0.006	...
EM7	¼-in. plate	0.033	17.93	13.51	2.47	1.77	0.31	0.023	0.006	...
EW5	1/16-in. sheet	0.033	17.93	13.51	2.47	1.77	0.31	0.023	0.006	...
EW6	1/16-in. sheet	0.053	17.36	12.68	1.89	1.60	0.44	0.023	0.023	...
FH1A	3/16-in. plate	0.027	17.96	11.36	2.32	1.44	0.59	...	...	0.013
FH3A	¼-in. plate	0.022	17.72	11.04	2.42	1.30	0.37	...	...	0.032
FH4A	3/16-in. plate	0.024	17.56	11.20	2.20	0.90	0.29	...	...	0.033
FH5A	¼-in. plate	0.026	17.70	13.18	2.40	0.80	0.46	...	...	0.13
FH8A	¼-in. plate	0.017	17.45	12.98	2.40	1.08	0.28	...	...	0.026
FH9A	¼-in. plate	0.019	17.12	13.36	2.65	1.06	0.28	...	...	0.028
FI1A	¼-in. plate	0.021	17.70	12.88	2.36	1.00	0.29	...	...	0.033
FI2A	¼-in. plate	0.022	17.33	12.91	2.28	0.90	0.36	...	...	0.031
FI3A	3/16-in. plate	0.020	18.24	13.22	2.23	1.12	0.37	...	...	0.030
FI4A	¼-in. plate	0.020	16.16	13.22	2.20	1.60	0.47	...	...	0.029
FI5A	¼-in. plate	0.022	17.91	12.61	2.40	1.00	0.43	...	...	0.031
FI6A	¼-in. plate	0.022	18.85	12.75	2.37	1.85	0.44	...	...	0.031
FI7A	¼-in. plate	0.024	17.92	12.50	2.42	1.30	0.26	...	...	0.031
FI8A	¼-in. plate	0.022	17.87	13.12	2.80	1.16	0.45	...	...	0.032
FI9A	¼-in. plate	0.018	18.54	12.84	3.00	0.71	0.27	...	...	0.027
FJ1A	5/16-in. plate	0.019	18.56	12.64	2.85	1.06	0.38	...	...	0.031
FJ2A	5/16-in. plate	0.022	18.45	12.69	3.03	1.25	0.31	...	...	0.025
FJ3A	¼-in. plate	0.018	17.32	13.79	3.28	0.86	0.35	...	...	0.028
FJ4A	¼-in. plate	0.022	18.51	12.86	2.78	1.49	0.36	...	...	0.13
FJ5A	¼-in. plate	0.023	18.43	12.86	2.86	1.41	0.39	...	...	0.12
FJ6A	¼-in. plate	0.022	17.26	14.10	2.94	1.46	0.36	...	...	0.029
FJ7A	¼-in. plate	0.026	17.84	13.67	2.95	0.93	0.42	...	...	0.029
FX2	¼-in. plate	0.05	18.07	12.68	2.38	1.78	0.36	0.016	0.007	...
GC3	⅛-in. sheet	0.060	17.78	12.79	2.20	1.74	0.53	0.023	0.017	...
GC4	⅛-in. sheet	0.028	17.20	13.35	2.49	1.79	0.48	0.025	0.010	...
GI7	⅛-in. sheet	0.025	18.54	13.76	2.75	1.39	0.46	0.021	0.017	...
GU2	¼-in. plate	0.024	17.93	10.58	2.35	1.25	0.34	...	...	...
GU3	¼-in. plate	0.024	16.84	10.42	2.55	0.90	0.36	...	...	...
GU4	¼-in. plate	0.022	18.52	12.93	2.40	1.30	0.29	...	...	...
GU5	¼-in. plate	0.019	17.47	11.83	2.80	1.41	0.36	...	...	...
GU6	¼-in. plate	0.025	18.16	12.05	2.90	1.24	0.37	...	...	...
GU7	¼-in. plate	0.030	18.05	10.54	2.30	1.42	0.35	...	...	...
GW1	3/16-in. plate	0.023	17.87	13.28	2.17	1.67	0.66	0.020	0.012	...
GW4	⅛-in. sheet	0.023	17.98	13.68	2.31	1.81	0.53	0.022	0.019	...
GW6	½-in. plate	0.028	17.82	13.15	2.26	1.79	0.60	0.025	0.010	...
GW7	⅜-in. plate	0.022	17.72	13.49	2.33	1.95	0.53	0.022	0.015	...
GW8	5/16-in. plate	0.019	17.80	13.47	2.25	1.90	0.60	0.020	0.011	...
GW9	7/16-in. plate	0.018	17.76	13.54	2.23	1.56	0.45	0.022	0.012	...
GX5	⅛-in. sheet	0.029	17.60	13.64	2.27	2.00	0.54	0.023	0.020	...
GX6	⅛-in. sheet	0.021	17.41	13.62	2.33	1.84	0.55	0.022	0.010	...
GY5	¼-in. plate	0.046	17.70	13.00	2.15	2.00	0.59	0.025	0.010	...
GY6	¼-in. plate	0.041	17.55	13.35	2.42	1.66	0.50	0.025	0.021	...
GY7	¼-in. plate	0.043	17.86	13.08	2.20	1.79	0.51	0.030	0.016	...
HA3	1/16-in. sheet	0.024	17.85	13.00	2.15	1.42	0.37	0.023	0.015	...
HA4	⅛-in. sheet	0.024	17.70	12.95	2.10	1.66	0.15	0.024	0.019	...
HA5	⅛-in. sheet	0.021	17.56	12.35	2.24	1.62	0.41	0.025	0.017	...
HA6	⅛-in. sheet	0.024	17.62	12.81	2.18	1.68	0.31	0.028	0.016	...
HE4	⅛-in. sheet	0.021	19.08	12.60	2.10	0.72	0.43	0.018	0.011	...
HE5	⅛-in. sheet	0.025	19.49	12.56	2.24	0.74	0.30	0.032	0.014	...
HI2	⅛-in. sheet	0.025	18.97	12.72	2.20	0.91	0.45	0.027	0.017	...
HP3-716	⅞-in. hex. bar	0.040	17.73	13.16	2.37	1.83	0.31	0.023	0.013	...
HP6	¼-in. plate	0.042	17.41	13.24	2.29	1.65	0.54	0.022	0.016	...
HP7	¼-in. plate	0.04	17.45	13.33	2.05	1.87	0.50	0.021	0.016	...
HP8	¼-in. plate	0.053	17.44	13.20	2.28	1.42	0.42	0.023	0.015	...
HR1-1	⅜-in. plate	0.026	17.78	13.58	2.58	1.85	0.57	0.027	0.016	...
HR1-3	9/16-in. plate	0.025	17.77	13.50	2.65	1.75	0.44	0.019	0.020	...
HR1-5	⅜-in. plate	0.026	17.80	13.37	2.72	1.55	0.52	0.022	0.012	...
HR1-7	½-in. plate	0.024	17.77	13.53	2.27	1.73	0.42	0.019	0.012	...
HR1-9	⅛-in. sheet	0.021	17.58	13.64	2.03	1.75	0.57	0.020	0.016	...
HR1-11	7/16-in. plate	0.025	18.09	13.21	2.64	1.71	0.48	0.020	0.017	...
HR1-13	⅛-in. sheet	0.028	17.24	13.66	2.23	1.78	0.51	0.023	0.015	...
HR1-15	7/16-in. plate	0.029	17.65	13.09	2.21	1.74	0.52	0.027	0.021	...
HR1-19	7/16-in. plate	0.029	17.65	13.09	2.21	1.74	0.52	0.027	0.021	...
HR1-17	1-in. plate	0.024	17.97	13.55	2.69	1.74	0.59	0.020	0.014	...
HR1-21	7/16-in. plate	0.028	18.21	13.43	2.50	1.88	0.69	0.029	0.022	...
HR1-23	7/16-in. plate	0.028	18.21	13.43	2.50	1.88	0.69	0.029	0.022	...
HR1-25	⅜-in. plate	0.029	17.41	13.64	2.80	1.63	0.55	0.022	0.010	...
HR1-27	⅜-in. plate	0.029	17.41	13.64	2.80	1.63	0.55	0.022	0.010	...
HR4-3	1-in. plate	0.030	17.70	12.35	2.30	1.70	0.88	0.025	0.006	...
HR4-5	3/16-in. plate	0.026	17.60	12.65	2.00	1.60	0.54	0.030	0.014	...
HR4-8	¾-in. plate	0.030	17.40	12.62	2.28	1.44	0.39	0.028	0.013	...
MY316	¼-in. plate	0.046	17.39	12.70	2.42	1.68	0.61	...	...	...

[a] Designations for 86 samples representing 80 different commercial heats of types 316 and 316L stainless steel. These heats were obtained from four different steel producers: Producer A (40 heats), Producer B (36 heats), Producer C (3 heats), and Producer D (1 heat).

[b] Carbon analyses are ladle or heat analyses as reported by the steel producer. Check carbon analyses for some of these samples are included in Table VI.

Care was taken to insure that all of the steels were in the fully annealed condition prior to evaluation by the nitric-hydrofluoric acid test, that is, that there was no evidence of either precipitated carbides or prior plastic deformation. No steels were evaluated unless they showed, in the commercially annealed condition, both a step (annealed) structure in the electrolytic oxalic acid etching test and a corrosion rate of 0.0010 in. per month or less (no appreciable intergranular corrosion) in the standard nitric acid test.

Sample Size, Preparation, and Heat Treatment

The corrosion specimens were sufficient in size to provide a minimum of 1 sq in. of surface area. Most specimens had a surface area of 1.5 to 2.5 sq in. All specimens were given an 80-grit finish by belt grinding prior to corrosion testing.

Specimens to be tested in the sensitized condition were given a 1-hr at 1250 F heat treatment in a combustion-type tube furnace, followed by water quenching. The temperature of the specimens during heat treatment was controlled to within ±10 F.

Methods Used to Evaluate Samples

Two methods were used to evaluate the intergranular corrosion resistance of each heat of steel: (1) the electrolytic oxalic acid etching test and (2) the 10 per cent nitric – 3 per cent hydrofluoric acid test. The steels were evaluated in the commercially annealed condition and in the sensitized condition (1 hr at 1250 F, WQ). The electrolytic oxalic acid etching test was made on the same two specimens of each heat that were subsequently exposed to the nitric-hydrofluoric acid test.

Electrolytic Oxalic Acid Etching Test

The standard ASTM procedure[9] was followed in making the electrolytic oxalic etching test. In the present study the test was always made on the cross-sectional or end face of the specimen in order to detect carburization, decarburization, or end-face pitting. The surface to be examined was prepared by grinding through No. 000 emery paper. The specimen was then electrolytically etched in a 10 per cent oxalic acid solution for 1.5 min at a current density of 1 amp per sq cm. Finally, the etched surface was microscopically examined at a magnification of 250 to 500×.

The structure produced by the test was classified as either step (no carbide precipitation at the grain boundaries), dual (carbide precipitation, but not enough to completely encircle any of the grains), or ditch (one or more grains completely encircled by carbide precipitation). In the case of specimens having ditch structures, the percentage of encircled grains was estimated and the ASTM grain size was measured. It was recognized that these last two factors could influence the severity of intergranular corrosion in the nitric-hydrofluoric acid test. The number of encircled grains determines the continuity of the intergranular attack, while the grain size influences the time required to undermine the grains and drop them out of the corroding surface.

10 per cent Nitric – 3 per cent Hydrofluoric Acid Test

Test Solution.[10]—The 10 per cent nitric – 3 per cent hydrofluoric acid solution (by weight) was prepared by mixing 111 ml of 65 per cent nitric acid (sp gr 1.39), 54 ml of 48 per cent hydrofluoric acid (sp gr 1.16), and 784 ml of distilled water in a polyethylene carboy. Fresh test solution was made up daily, because evaporation of the hydrofluoric acid appreciably changed the concentration of the solution when storage times exceeded 24 hr.

Test Methods and Equipment.—Each specimen was individually exposed in approximately 200 ml of the test solution. Fresh acid solution was used for each test period.

The tests were conducted in specially designed cylinders of poly(vinyl chloride) (PVC) as shown in Fig. 1. The test cylinders were made by (*a*) cutting PVC pipe ($1\frac{1}{4}$-in. inside diameter by $\frac{3}{16}$-in. wall) into 12-in. lengths, (*b*) plugging each length at one end with a disk of $\frac{3}{16}$-in. PVC sheet, and (*c*) heat welding the disk in place with PVC filler rod. (The test cylinders can also be fabricated by solvent welding a $1\frac{1}{4}$-in. PVC socket type cap onto one end of a 12-in. length of $1\frac{1}{4}$-in. PVC pipe.) A rubber stopper protected by polyethylene sheet was used to close the open end of the test cylinder. A glass tube partially filled with water acted as a vapor trap or condenser.

The specimen holders were made of 1-in. lengths of Teflon[11] tubing (1-in. inside diameter) drilled at one end to accommodate a $\frac{3}{16}$-in. Teflon rod. The holders were flattened into an elliptical shape which was maintained by inserting the Teflon rod through the two holes and upsetting the ends of the rod with a hammer. A loop of Teflon cord was then attached to each specimen holder and used to suspend it in the test cylinder. (An alternate type of specimen holder can be made from a $\frac{1}{2}$-in. PVC socket type cap by machining the outside diameter to $1\frac{1}{16}$ in.)

The desired test temperatures were obtained by placing the PVC cylinders within a rack in a constant-temperature water bath. The temperature of the bath was maintained at 2 to 3 C above the desired solution temperature to offset the low thermal conductivity of the poly(vinyl chloride). The temperature of the acid solution, which was measured at the beginning and end of each test period, was controlled to within ±0.5 C.

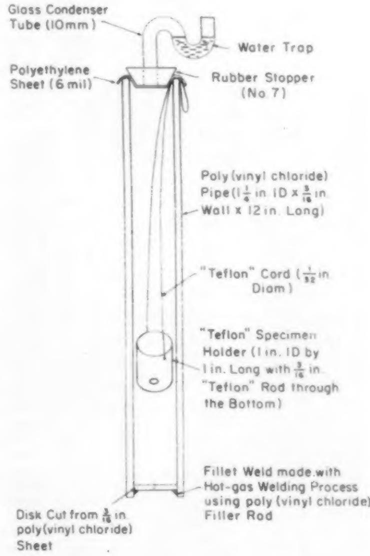

Fig. 1.—Sketch of test cylinder and specimen holder used in making nitric-hydrofluoric acid test.

Evaluation Methods.—The results of the nitric-hydrofluoric acid testing were evaluated by means of weight-loss measurements and macroscopic observations (7.5 to 75×), made at the end of each test period. The weight losses were translated into corrosion rates measured in inches per month. The ratio of the corrosion rate for the sensitized condition to that for the annealed condition was used to evaluate the amount of intergranular corrosion on the sensitized sample. Macroscopic observations were concerned with the severity of the intergranular attack on the sensitized sample and the degree of grain dropping which had occurred.

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[10] *Precautionary Note.*—THE 10 PER CENT NITRIC, 3 PER CENT HYDROFLUORIC ACID SOLUTION WILL CAUSE SEVERE BURNS if it comes into contact with the skin. Therefore, extreme care should be exercised in handling this solution. Rubber gloves should be worn. Spilled acid should be immediately washed from the skin with an excess of water and emergency first aid treatment obtained.

[11] Du Pont trademark for tetrafluoroethylene resin.

DISCUSSION OF RESULTS

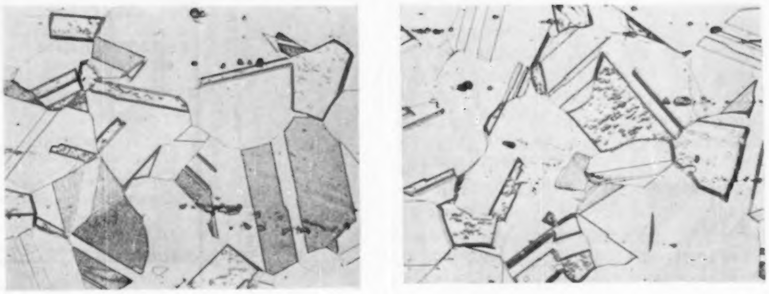
Development of Test Procedure

The concentration of the test solution was standardized at 10 per cent nitric – 3 per cent hydrofluoric acid (by weight), because this concentration appeared to be the most widely used (**1,2, 5,11,12**). However, research was necessary to determine the best test conditions: test temperature, length of test period, and total length of test. Chosen for this initial research were three heats of types 316 and 316L stainless steel which varied quite widely in their oxalic acid etch structures and in their susceptibility to intergranular attack in a nitric-hydrofluoric acid solution. Results of a preliminary study on these heats are summarized in Table III; the accompanying oxalic acid etch structures are illustrated in Figs. 2, 3, and 4.

Figure 5 graphically shows the differences in corrosion behavior of the three heats when exposed to a 10 per cent nitric – 3 per cent hydrofluoric acid solution at 70 C for five ½-hr test periods. The data for the curves in Fig. 5 were obtained by converting the weight loss in grams per square centimeter for each test period into the equivalent amount of metal lost in mils (corrosion was assumed to be uniform over the entire surface of the specimen). In the case of the 0.022 per cent carbon heat (FI2A), the sensitized specimen was comparatively free of precipitated carbides (see step structure of Fig. 2) and consequently was not intergranularly attacked. Thus, the sensitized specimen of heat FI2A corroded at the same rate as the annealed specimen. Sensitized specimens of the other two heats, EM7 and MY316, underwent severe intergranular attack due to a grain-boundary network of precipitated carbides (see ditch structure in Figs. 3 and 4). As a result, the sensitized specimens of these two heats were dropping grains from their surfaces at the end of the first ½-hr test period. This grain dropping is reflected in the increasing slope of the corrosion curves for the sensitized specimens of heats EM7 and MY316. The sensitized specimen of heat MY316, with 90 per cent of its grains completely encircled by carbides, was intergranularly corroding and dropping grains much more rapidly than the sensitized specimen of heat EM7, with less than 5 per cent of its grains encircled by carbides.

Effect of Test Temperature

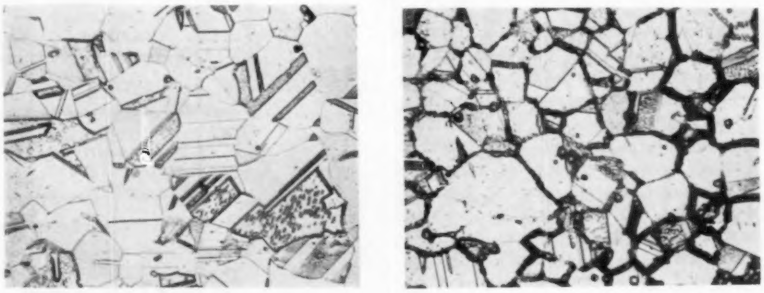
Of the three test temperatures investigated (60, 70, and 80 C), 70 C appeared the most desirable. As shown in Table IV, the rate of general corrosive attack



Condition: Commercially annealed
Etch structure: Step

Condition: Sensitized 1 hr at 1250 F, WQ
Etch structure: Step

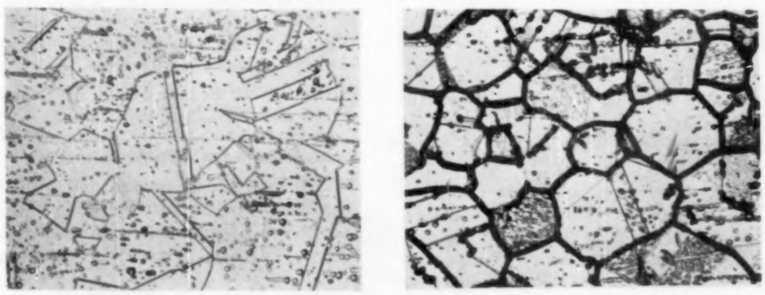
Fig. 2.—Etch structures for heat FI2A (0.022 per cent Carbon) produced by the electrolytic oxalic acid etching test (×250).



Condition: Commercially annealed
Etch structure: Step

Condition: Sensitized 1 hr at 1250 F, WQ
Etch structure: Ditch (less than 5 per cent encircled grains)

Fig. 3.—Etch structures for heat EM7 (0.033 per cent Carbon) produced by the electrolytic oxalic acid etching test (×250).



Condition: Commercially annealed
Etch structure: Step

Condition: Sensitized 1 hr at 1250 F, WQ
Etch structure: Ditch (90 per cent encircled grains)

Fig. 4.—Etch structures for heat MY316 (0.046 per cent Carbon) produced by the electrolytic oxalic acid etching test (×250).

TABLE III.—PRELIMINARY DATA FOR THREE HEATS OF TYPES 316 AND 316L STAINLESS STEEL USED IN DEVELOPMENT OF TEST PROCEDURE FOR 10 PER CENT NITRIC – 3 PER CENT HYDROFLUORIC ACID SOLUTION.

Heat Number[a]	Carbon Content, per cent	Electrolytic Oxalic Acid Etch Structure for Sensitized Specimen[b]		HNO_3-HF Ratio[d]
		Classification	Encircled Grains,[c] per cent	
FI2A	0.022	Step	0	1.0
EM7	0.033	Ditch	<5	2.3
MY316	0.046	Ditch	90	12

[a] See Table II for complete chemical compositions of these heats.
[b] Specimen sensitized by heating for 1 hr at 1250 F, WQ and electrolytically etched in 10 per cent oxalic acid for 1.5 min at 1 amp per sq cm.
[c] Percentage of grains completely encircled by carbide precipitation.
[d] Ratios were obtained by dividing the corrosion rate for the sensitized condition (1 hr at 1250 F, WQ) by the corrosion rate for the annealed condition. Corrosion rates are based on tests in a 10 per cent nitric – 3 per cent hydrofluoric acid solution at 70 C for five ½-hr periods.

(annealed corrosion rate) increased rapidly with increasing test temperature. Increasing the test temperature had very little effect on the severity of the intergranular attack on the sensitized samples (compare ratios of sensitized-to-annealed corrosion rates). Although not shown in Table IV, difficulty was sometimes encountered at 60 C in obtaining reproducible corrosion rates for annealed specimens from one test period to the next. Consequently, a 70 C test temperature offered the best compromise between adequate reproducibility and lowest rate of general attack.

Effect of Length of Test Period and Total Length of Test

Investigation of these two variables indicated that use of two 2-hr test periods would be the best procedure for evaluation of stainless steels with a 10 per cent nitric – 3 per cent hydrofluoric acid solution at 70 C. The data in Table V show the effect of (*a*) variations in the length of test period (½, 1, 2, and 4 hr) and (*b*) variations in the total length of test (½ to 4 hr).

Increasing the total length of test increased the ratio of the sensitized corrosion rate to the annealed corrosion rate for those heats susceptible to intergranular attack (heats EM7 and MY316). A total test time of 4 hr was sufficient to distinguish between borderline material (heat EM7 with 0.033 per cent carbon) and completely acceptable material (heat FI2A with 0.022 carbon) on the basis of their nitric-hydrofluoric acid test ratio. For example, after a total test time of 4 hr, heat EM7 had a ratio of 2.0 to 2.5, while heat FI2A had a ratio of 1.0.

For a constant total test time, the length of the individual test periods had little or no effect on the ratio of the sensitized-to-annealed corrosion rate of the three heats. These results indicate that the accumulation of corrosion products in the test solution did not lead to accelerated intergranular attack on the sensitized specimens. This is in contrast to the standard nitric acid test, where accumulation of excessive amounts of chromium ion causes accelerated intergranular corrosion (**15,16**). Increasing the length of the test period did reduce the general, or annealed, corrosion rate slightly due to acid depletion. (Compare the corrosion rates for the annealed condition at the end of 2 and 4 hr of testing for the various test periods used.)

Use of two 2-hr test periods was selected as the best test procedure because it provided adequate ratios and minimized the number of individual weighings. It was felt that at least three weighings were necessary to avoid errors.

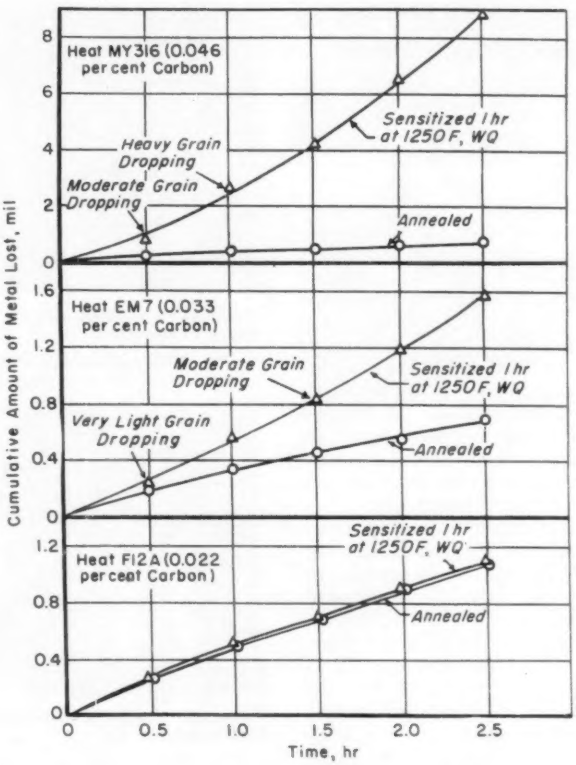


Fig. 5.—Corrosion of types 316 and 316L stainless steel in a 10 per cent HNO_3, 3 per cent HF solution at 70 C.

Evaluation of Eighty Heats of Types 316 and 316L Stainless Steel

General Corrosion Resistance

As previously mentioned, hot nitric-hydrofluoric acid solutions produce severe general attack on annealed stainless steels. This attack results in high corrosion rates which vary widely with compositional differences in the steel. As shown by Table VI, the annealed corrosion rates for 80 heats of types 316 and 316L stainless steel exposed to a 10 per cent nitric – 3 per cent hydrofluoric acid solution at 70 C varied from 0.09 to 0.54 in. per month. (Most of the

TABLE IV.—EFFECT OF TEST TEMPERATURE ON (*a*) THE GENERAL CORROSION RATE AND (*b*) THE RATIO OF SENSITIZED CORROSION RATE TO ANNEALED CORROSION RATE IN A 10 PER CENT HNO_3 – 3 PER CENT HF SOLUTION.

Heat Number	Carbon Content of Steel, per cent	Test Temperature, deg cent	Corrosion Rate for Annealed Condition, in. per month[a]	HNO_3-HF Ratio Based on ½-hr Test Periods[b]				
				First Period	Two Period Average	Three Period Average	Four Period Average	Five Period Average
FI2A.....	0.022	60	0.19	1.1	1.0	1.0	1.0	1.0
		70	0.31	1.0	1.0	1.0	1.0	1.0
		80	0.49	1.0	0.9	1.0	1.0	1.0
EM7.....	0.033	60	0.12	1.2	1.6	1.8	2.0	2.1
		70	0.20	1.3	1.7	1.8	2.1	2.3
		80	0.28	1.4	1.7	2.0	2.2	2.5
MY316...	0.046	60	0.15	4.5	7.5	9.0	11	12
		70	0.22	4.3	7.0	8.5	10	12
		80	0.37	5.5	8.0	11	13	14

[a] Average corrosion rate for commercially-annealed material exposed to a 10 per cent HNO_3 – 3 per cent HF solution for five ½-hr periods at the indicated temperature. Fresh acid solution was used for each test period.

[b] Ratios were obtained by dividing the corrosion rate for the sensitized condition (1 hr at 1250 F, WQ) by the corrosion rate for the annealed condition.

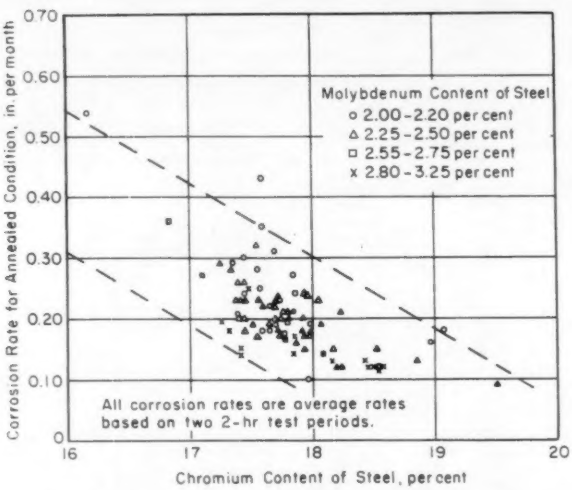


Fig. 6.—Effect of chromium and molybdenum content on the corrosion rate of annealed types 316 and 316L stainless steel in a 10 per cent HNO_3, 3 per cent HF solution at 70 C.

rates fell within the range of 0.10 to 0.30 in. per month.) Figure 6 shows that, in general, the annealed corrosion rate of types 316 and 316L stainless steel in a hot nitric-hydrofluoric acid solution decreases with increasing chromium and increasing molybdenum content. Zitter (**17**) has shown a similar effect of chromium content on the annealed corrosion rate of type 304 stainless steel exposed for 5 hr to a 10 per cent nitric – 3 per cent hydrofluoric acid solution at 75 C.

The above results emphasize the need for using the ratio of the sensitized-to-annealed corrosion rate, rather than the sensitized corrosion rate alone, in evaluating the intergranular corrosion resistance of stainless steels by the nitric-hydrofluoric acid test. Use of the ratio minimizes the effect of variations in the general corrosion rates obtained for different heats of the same type of steel.

Intergranular Corrosion Resistance

The results of evaluating 80 heats of types 316 and 316L stainless steel by the electrolytic oxalic acid etching test and by the nitric-hydrofluoric acid test are tabulated in Table VI and are graphically shown in Fig. 7.

Electrolytic Oxalic Acid Etching Test.—Of sixty-five[12] heats of type 316L stainless steel (0.03 per cent max carbon), 61, or 94 per cent, had an oxalic acid etch structure of either step or dual in the sensitized condition. These etch structures indicate freedom from damaging carbide precipitation, that is, insufficient carbide precipitation to seriously affect the intergranular corrosion resistance of the steel. The remaining four heats of type 316L, or 6 per cent, had a ditch structure in the sensitized condition, indicating that the carbide precipitation might be sufficient to damage the intergranular corrosion resistance.

Of twenty-one[13] heats of type 316 stainless steel (more than 0.03 per cent max carbon), fifteen, or 71 per cent, had a ditch structure in the sensitized condition. Six heats of type 316, or 29 per cent, were free from damaging carbide precipitation in the sensitized condition as evidenced by a dual structure.

Nitric-Hydrofluoric Acid Test.—Ratios of the sensitized corrosion rate to the annealed corrosion rate in the nitric-hydrofluoric acid test ranged from 0.8 to 24 for the 80 heats of steel evaluated. All tests were made in a 10 per cent nitric – 3 per cent hydrofluoric acid solution at 70 C for two 2-hr periods. Those heats which underwent little or no intergranular attack and grain dropping in the sensitized condition had a nitric-hydrofluoric acid test ratio of 0.8 to 1.3, that is, a ratio of approximately one.[14]

[12] Actually 65 different samples representing 62 different heats.

[13] Actually 21 different samples representing 18 different heats.

[14] The range of 0.8 to 1.3 represents the maximum accuracy with which this test can define the ratio for material free from susceptibility to intergranular attack. In some cases, a sensitized specimen underwent localized intergranular attack and slight grain dropping without increasing the test ratio above 1.3. However, in every case where the sensitized specimen underwent severe intergranular attack and moderate to heavy grain dropping of a uniform nature, the test ratio was 1.8 or greater.

TABLE V.—EFFECT OF TOTAL TEST TIME AND LENGTH OF TEST PERIOD ON (*a*) THE GENERAL CORROSION RATE AND (*b*) THE RATIO OF SENSITIZED CORROSION RATE TO ANNEALED CORROSION RATE IN A 10 PER CENT HNO_3 – 3 PER CENT HF SOLUTION AT 70 C.

Heat Number	Carbon Content of Steel, per cent	Total Test Time, hr	Corrosion Rate for Annealed Condition, in. per month[a]				HNO_3-HF Ratio[b]			
			½-hr Test Periods	1-hr Test Periods	2-hr Test Periods	4-hr Test Periods	½-hr Test Periods	1-hr Test Periods	2-hr Test Periods	4-hr Test Periods
FI2A	0.022	½	0.39	..	..	..	1.0	..	..	..
		1	0.36	0.29	..	..	1.0	1.0	..	..
		2	0.32	0.28	0.28	..	1.0	1.0	1.0	..
		4	..	0.28	0.28	0.26	1.0	1.0	1.0	1.0
EM7	0.033	½	0.26	..	..	..	1.3	..	..	..
		1	0.24	0.19	..	..	1.7	1.3	..	..
		2	0.20	0.18	0.18	..	2.1	1.6	1.8	..
		4	..	0.18	0.17	0.16	..	2.0	2.2	2.5
MY316	0.046	½	0.28	..	..	..	4.3	..	..	..
		1	0.26	0.19	..	..	7.0	7.0	..	..
		2	0.23	0.20	0.20	..	10	10	10	..
		4	..	0.19	0.19	0.18	..	15	14	14

[a] Average corrosion rate for commercially-annealed material exposed to a 10 per cent HNO_3 – 3 per cent HF Solution at 70 C. Fresh acid solution was used for each test period.

[b] Ratios were obtained by dividing the corrosion rate for the sensitized condition (1 hr at 1250 F, WQ) by the corrosion rate for the annealed condition.

TABLE VI.—TEST DATA FOR EIGHTY COMMERCIAL HEATS OF TYPES 316 AND 316L STAINLESS STEEL EVALUATED BY THE ELECTROLYTIC OXALIC ACID ETCHING TEST AND BY A 10 PER CENT NITRIC–3 PER CENT HYDROFLUORIC ACID TEST AT 70 C.

Heat Number[a]	Carbon Content, per cent		Results of HNO_3-HF Test[d]			Microstructural Observations—Sensitized Sample			
	Heat Analysis[b]	Check Analysis[c]	Annealed Corrosion Rate, in. per month	Ratio[e]	Degree of Grain Dropping[f]	Electrolytic Oxalic Acid Etch Structure[g]: Classification	Comments	Encircled Grains, per cent[h]	Grain Size[i]
FH8A	0.017	...	0.26	1.0	None	Step		...	...
FJ3A	0.018	...	0.18	1.0	None	Step		...	...
FI9A	0.018	...	0.12	0.9	None	Step		...	...
GW9	0.018	...	0.20	1.0	None	Step		...	...
GU5	0.019	...	0.25	1.0	None	Dual	Mostly step with extremely mild dual next to surface	...	...
FJ1A	0.019	...	0.12	1.0	None	Step		...	...
FH9A	0.019	...	0.27	1.0	None	Step		...	...
GW8	0.019	...	0.21	0.9	None	Step		...	...
FI3A	0.020	...	0.21	1.0	None	Step		...	...
FI4A	0.020	...	0.54	1.0	None	Step		...	...
HR1-9	0.021	...	0.25	1.0	None	Step		...	...
FI1A	0.021	...	0.23	1.0	None	Step		...	...
GX6	0.021	...	0.26	1.0	None	Step		...	...
HA5	0.021	...	0.32	1.1	None	Step		...	...
HE4	0.021	...	0.18	1.1	Light	Dual	Mostly step with mild dual next to surface	...	...
FJ6A	0.022	...	0.19	1.0	None	Step		...	...
EI6	0.022	0.022	0.16	1.1	Light	Dual	Nonuniform structure varying from step to dual	...	...
FH3A	0.022	...	0.23	0.9	None	Step		...	...
FI2A	0.022	...	0.28	1.0	None	Step		...	...
FI5A	0.022	...	0.18	0.9	None	Step		...	...
FI6A	0.022	...	0.13	0.8	None	Step		...	...
FJ2A	0.022	...	0.12	0.9	None	Step		...	...
GU4	0.022	...	0.15	0.9	None	Dual	Mostly step with extremely mild dual next to surface	...	...
GW7	0.022	...	0.18	1.2	None	Step		...	...
FI8A	0.022	...	0.17	1.0	None	Step		...	...
FJ4A	0.022	...	0.12	0.9	None	Step		...	...
FJ5A	0.023	...	0.13	1.0	None	Step		...	...
GW1	0.023	...	0.24	1.0	None	Step		...	...
GW4	0.023	...	0.18	1.1	None	Step		...	...
HR1-17	0.024	...	0.10	1.0	None	Step		...	...
CX9-451	0.024	...	0.15	0.9	None	Step		...	...
HR1-7	0.024	...	0.21	1.2	None	Step		...	...
FH4A	0.024	...	0.28	1.0	None	Step		...	...
FI7A	0.024	...	0.20	1.0	None	Step		...	...
GU2	0.024	...	0.24	0.9	None	Step		...	...
GU3	0.024	...	0.36	1.1	Light	Dual	Mostly step with mild dual next to surface	...	...
HA3	0.024	...	0.27	1.0	None	Step		...	...
HA4	0.024	...	0.31	1.2	Light	Dual	Very mild dual	...	...
HA6	0.024	...	0.35	1.1	None	Step		...	...
HR1-11	0.025	...	0.14	1.0	None	Step		...	...
HR1-3	0.025	...	0.17	1.0	None	Step		...	...
HE5	0.025	0.024	0.09	1.2	Light	Ditch	Nonuniform structure varying from dual to ditch	<5	3–4
GI7	0.025	...	0.12	1.3	None	Step		...	...
GU6	0.025	...	0.13	0.8	None	Step		...	...
HI2	0.025	...	0.16	1.0	None	Dual	Mostly step with mild dual next to surface	...	...
HR1-1	0.026	...	0.17	1.0	None	Dual		...	...
HR4-5	0.026	...	0.43	1.0	None	Step		...	...
FJ7A	0.026	0.023	0.14	1.0	None	Dual	Mild dual	...	...
FH5A	0.026	...	0.20	1.0	None	Step		...	...
FH1A	0.027	...	0.24	1.0	Light	Dual	Mild dual in interior; heavy dual next to surface	...	...
GW6	0.028	0.025	0.20	1.1	Light	Ditch	Dual in interior; ditch next to surface	<5	4–5
GX5	0.029	0.025	0.22	1.0	None	Step		...	...
HR1-13	0.028	...	0.29	1.3	None	Step		...	...
HR1-21	0.028	...	0.12	0.9	None	Step		...	...
HR1-23	0.028	...	0.12	1.0	None	Step		...	...
CX9-457	0.028	...	0.19	1.0	None	Step		...	...
GC4	0.028	0.028	0.20	4.0	Heavy	Ditch		25–30	3–4
HR1-15	0.029	...	0.18	1.2	Light	Dual	Mild dual	...	...
HR1-19	0.029	...	0.22	1.0	Light	Dual		...	...
HR1-25	0.029	...	0.15	1.0	None	Step		...	...
HR1-27	0.029	...	0.14	1.1	None	Dual		...	...
GU7	0.030	0.029	0.23	0.9	None	Dual	Mostly step with very mild dual next to surface	...	...
HR4-8	0.030	...	0.23	1.2	Light	Dual	Mild dual	...	...
HR4-3	0.030	0.029	0.22	1.8	Moderate	Ditch		5–10	5–6
D61	0.031	0.028	0.23	1.1	Light	Dual	Mild dual	...	...
D63	0.031	...	0.23	1.1	Light	Dual	Mild dual	...	...
EM6	0.033	0.030	0.15	4.7	Mod.-heavy	Ditch	50–75 per cent of the grains next to surface were encircled	5–10	5–6
EM7	0.033	0.034	0.17	2.2	Moderate	Ditch	Mostly dual with localized ditching	<5	5

TABLE VI. (*Continued*)—TEST DATA FOR EIGHTY COMMERCIAL HEATS OF TYPES 316 AND 316L STAINLESS STEEL EVALUATED BY THE ELECTROLYTIC OXALIC ACID ETCHING TEST AND BY A 10 PER CENT NITRIC-3 PER CENT HYDROFLUORIC ACID TEST AT 70 C.

Heat Number[a]	Carbon Content, per cent		Results of HNO_3-HF Test[d]			Microstructural Observations—Sensitized Sample			
	Heat Analysis[b]	Check Analysis[c]	Annealed Corrosion Rate, in./month	Ratio[e]	Degree of Grain Dropping[f]	Electrolytic Oxalic Acid Etch Structure[g]: Classification	Comments	Encircled Grains, per cent[h]	Grain Size[i]
HR1-5	0.026	0.040	0.20	1.8	Mod.-heavy	Ditch	Mostly dual with localized ditching next to surface	<5	4
EW5	0.033	0.040	0.17	7.5	Heavy	Ditch		75-80	6
HP7	0.040	0.040	0.24	1.1	Light	Dual	Mild dual	...	...
HP3-716	0.040	0.042	0.17	1.0	None	Dual	Mild dual	...	...
DY4-135	0.041	...	0.20	1.9	Mod.-heavy	Ditch	100 per cent of the grains next to surface were encircled	10	2-3
GY6	0.041	...	0.17	3.2	Mod.-heavy	Ditch	90 per cent of the grains next to surface were encircled	10	2-3
HP6	0.042	0.042	0.20	1.1	Light	Dual	Mild dual	...	...
BZ7-596	0.042	0.048	0.23	1.3	Light	Dual		...	...
GY7	0.043	...	0.21	3.7	Mod.-heavy	Ditch	90 per cent of the grains next to surface were encircled	10	5-6
CX9-453	0.045	...	0.19	2.3	Moderate	Ditch		10-20	3-4
MY316	0.046	0.048	0.19	14	Very heavy	Ditch		90	2-3
GY5	0.046	0.049	0.19	1.1	Light	Dual		...	...
FX2	0.050	...	0.19	3.4	Mod.-heavy	Ditch		30-40	2-3
CX9-455	0.050	...	0.18	3.7	Mod.-heavy	Ditch		40-50	4
HP8	0.053	0.053	0.18	2.1	Mod.-heavy	Ditch	Ditch next to surface; mild dual in interior	5-10	4
EW6	0.053	...	0.29	(20)	Very heavy	Ditch		90	6-7
DS5	0.055	...	0.30	7.5	Heavy	Ditch		60-70	1-2
GC3	0.060	...	0.23	(24)	Very heavy	Ditch		85-90	5

[a] Designations for 86 samples representing 80 different commercial heats of types 316 and 316L stainless steel.
[b] Ladle or heat analyses as reported by the steel producer.
[c] Laboratory analyses based on three or more determinations made with a Leco Carbon Conductometric Determinator.
[d] Test consisted of two 2-hr periods in a 10 per cent nitric – 3 per cent hydrofluoric acid solution at 70 C.
[e] Ratios were obtained by dividing the corrosion rate for the sensitized condition (1 hr at 1250 F, WQ) by the corrosion rate for the annealed condition. Parenthetical values for heats EW6 and GC3 are based on only one 2-hr test period.
[f] Estimated amount of grain dropping which had occurred on surface of sensitized specimens. Refers only to uniform grain dropping and not to localized attack of a spurious nature.
[g] Structure obtained by electrolytic etching of sensitized (1 hr at 1250 F, WQ) specimen in 10 per cent oxalic acid for 1.5 min at 1 amp per sq cm. This same sensitized specimen was used for the nitric-hydrofluoric acid test. All of the annealed specimens had a step structure after the electrolytic oxalic acid etching test.
[h] Percentage of grains completely encircled by carbide precipitation.
[i] Standard ASTM grain size number for ferrous materials.

Those heats of steel which in the sensitized condition underwent severe intergranular corrosion accompanied by moderate to heavy grain dropping had test ratios of 1.8 or greater. As shown by the data in Table VI, the nitric-hydrofluoric acid test ratio was greatest for those steels which had the highest percentage of carbide-encircled grains in the sensitized condition. Grain size had only a minor effect on the test ratio.

The above results indicate that a test ratio of 1.5 can be used to separate sensitized material that has not been damaged by carbide precipitation after sensitization from material that has been damaged. For example, of 65 heats of type 316L stainless steel, 63, or 97 per cent, had nitric-hydrofluoric acid test ratios of 1.3 or less. In contrast, 15 out of 21 type 316 heats, or 71 per cent, had test ratios of 1.8 or greater.

No difficulties were encountered in the nitric-hydrofluoric acid test from accelerated intergranular corrosion caused by end-face attack. End-face attack is a form of severe pitting or directional attack on the cross-sectional faces of the corrosion specimen. This type of attack frequently occurs in the

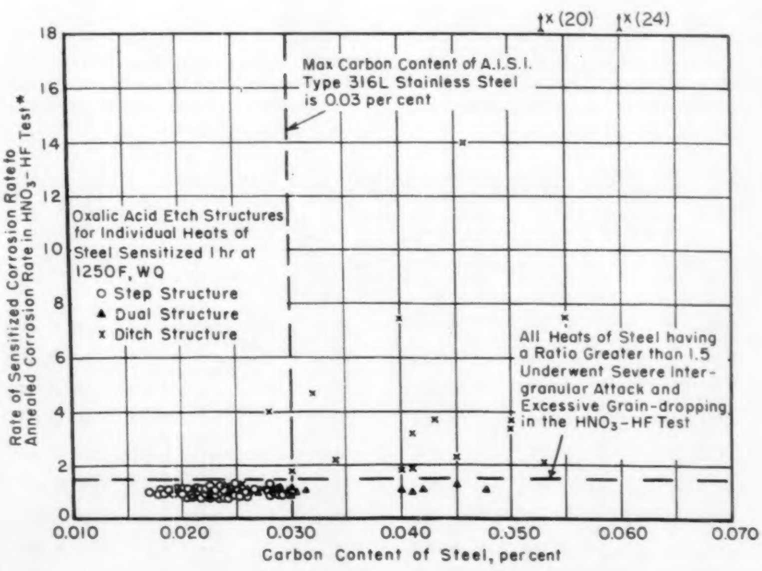


Fig. 7.—Comparative evaluation of eighty heats of types 316 and 316L stainless steel by the electrolytic oxalic acid etching test and by the 10 per cent nitric, 3 per cent hydrofluoric acid test.

*Test consisted of two 2-hr periods in a 10 per cent nitric–3 per cent hydrofluoric acid solution at 70 C.

standard nitric acid test and is accompanied by accelerated intergranular corrosion in the vicinity of the pits. While the nitric-hydrofluoric acid test did produce end-face pitting, the end-face attack was no more severe on the sensitized specimen than on the annealed specimen. Consequently, the end-face attack had no effect on the test ratio used to evaluate the susceptibility to intergranular corrosion.

Correlation Between the Two Evaluation Tests

Figure 7 shows the good correlation between the electrolytic oxalic acid etching test and the nitric-hydrofluoric acid test. Those heats having a step or dual structure (no damaging carbide precipitation) in the oxalic acid etching test had a ratio of approximately one (0.8 to 1.3) in the nitric-hydrofluoric acid test (no serious degree of intergranular attack). All but two of the nineteen heats having a ditch structure (damaging carbide precipitation) had nitric-hydrofluoric acid test ratios of 1.8 or greater (severe intergranular attack and extensive grain dropping). The two heats which had a ditch structure but nitric-hydrofluoric acid test ratios of only 1.1 and 1.2, were both type 316L stainless steel (carbon contents of these heats were 0.025 and 0.026 per cent).

One unexpected result of the evaluation studies was the sensitization behavior of five type 316 stainless steel heats whose carbon contents ranged from 0.040 to 0.046 per cent. These five heats when sensitized 1 hr at 1250 F had dual structures and nitric-hydrofluoric acid test ratios of 1.0 to 1.3. This type of behavior was surprising in view of the relatively high carbon contents involved. Check carbon analyses made on the actual test specimens from each heat of steel closely agreed with the carbon analyses reported by the producer. No explanation for the unusual resistance of these five heats to carbide precipitation upon sensitization is provided by their chemical compositions.

No attempt was made in these studies to correlate the results of the electrolytic oxalic acid etching test and nitric-hydrofluoric acid test with results of the standard nitric acid test. Such an attempt at correlation would only prove confusing, because the standard nitric acid test is sensitive to the presence of sigma phase and the other two tests are not.

Proposed Basis for Evaluation of Type 316L Stainless Steel

The data in Fig. 7 indicate that the following could be used as the criteria for type 316L stainless steel having adequate resistance to intergranular corrosion: (*a*) a step or dual structure in the electrolytic oxalic acid etching test for specimens sensitized 1 hr at 1250 F or (*b*) a maximum of 1.5 for the ratio of the sensitized (1 hr at 1250 F) corrosion rate to the annealed corrosion rate in the 10 per cent nitric – 3 per cent hydrofluoric acid test (two 2-hr periods at 70 C).

According to the compositional specifications of the American Iron and Steel Inst. type 316L stainless steel must have a maximum carbon content of 0.03 per cent. Sixty-five of the heats in the current study meet this requirement. Of these sixty-five heats 61, or 94 per cent, would have acceptable resistance to intergranular corrosion on the basis of their step or dual oxalic acid etch structure in the sensitized condition. In addition, two of the remaining four heats would have been acceptable on the basis of a ratio of 1.5 or less in the 10 per cent nitric – 3 per cent hydrofluoric acid test. Thus, 97 per cent of the 65 type 316L stainless steel heats showed adequate resistance to intergranular corrosion on the basis of the suggested criteria.

The above results indicate that the 10 per cent nitric – 3 per cent hydrofluoric acid test can be used in conjunction with the electrolytic oxalic acid etching test to evaluate in a reliable and fair manner the intergranular corrosion resistance of type 316L stainless steel. The usefulness of these tests is illustrated in the following. Two of the heats in the current study, HR1-5 and EW5, had reported carbon contents of 0.026 and 0.033 per cent, respectively. However, both of these heats had a ditch structure after being sensitized and oxalic acid etched. Their nitric-hydrofluoric acid test ratios were 1.8 and 7.5. These results led to a recheck of the carbon contents of the two heats; both steels had an actual carbon content of 0.040 per cent, instead of the lower values originally reported.

The fairness of the 10 per cent nitric – 3 per cent hydrofluoric acid test is illustrated by the fact that five heats of type 316 stainless steel had acceptable test ratios of less than 1.5, despite carbon contents ranging from 0.040 to 0.046 per cent. The electrolytic oxalic acid etching test confirmed these results by showing that the low nitric-hydrofluoric acid test ratios were due to insuffiicent carbide precipitation for complete grain

TABLE VII.—SUMMARY ANALYSIS OF PREVIOUSLY PUBLISHED CORROSION DATA FOR MOLYBDENUM-BEARING AUSTENITIC STAINLESS STEEL TESTED IN A 10 PER CENT NITRIC-3 PER CENT HYDROFLUORIC ACID SOLUTION.

Type of Steel	Heat Number[a]	Carbon Content, per cent	Test Conditions[b]		Sensitizing Treatment	Corrosion Rate, in. per month		HNO_3-HF Ratio[c]	Reference
			Temperature, deg Cent	Length of Test		Annealed	Sensitized		
316L	EQ2	0.025	73	Four ½-hr periods	1 hr, 1250 F, WQ	0.24	0.24	1.0	(*5*)
316	EW6	0.053	73	Four ½-hr periods	1 hr, 1250 F, WQ	0.30	6.6	22	(*5*)
317	EU8	0.07	73	Four ½-hr periods	1 hr, 1250 F, WQ	0.06	0.28	4.7	(*5*)
316L	M-62	0.004	70	Five 1-hr periods	2 hr, 1200 F, AC[d]	0.041	0.040	1.0	(*1*)
317L	M-63	0.006	70	Five 1-hr periods	2 hr, 1200 F, AC	0.029	0.028	1.0	(*1*)
316L	M-496	0.020	70	Five 1-hr periods	2 hr, 1200 F, AC	0.070	0.075	1.1	(*1*)
317L	M-497	0.023	70	Five 1-hr periods	2 hr, 1200 F, AC	0.032	0.033	1.0	(*1*)
316	M-480	0.066	70	Five 1-hr periods	2 hr, 1200 F, AC	0.065	0.26	4.0	(*1*)
317	M-481	0.067	70	Five 1-hr periods	2 hr, 1200 F, AC	0.037	0.20	5.4	(*1*)

[a] Number used by the authors of the respective papers to designate individual heats.
[b] All tests were made in a 10 per cent HNO_3 – 3 per cent HF solution.
[c] Ratios were obtained by dividing the corrosion rate for the sensitized condition by the corrosion rate for the annealed condition
[d] Air cooled.

encirclement (dual structure).

In the technical literature there exists only a limited amount of corrosion data on the testing of types 316 and 316L stainless steel in a 10 per cent nitric – 3 per cent hydrofluoric acid solution. These data of other investigators (**1,5**) are tabulated in Table VII along with the calculated ratios of the sensitized corrosion rate to annealed corrosion rate. The five heats of types 316L and 317L stainless steel had nitric-hydrofluoric acid test ratios of 1.0 to 1.1. In contrast, the test ratios for the four heats of types 316 and 317 stainless steel varied from 4.0 to 22. These latter ratios are all greater than the 1.5 criterion used in the current study for material having acceptable resistance to intergranular corrosion. Thus, the data in Table VII provide additional evidence that a 10 per cent nitric – 3 per cent hydrofluoric acid test can be successfully used to evaluate the intergranular corrosion resistance of type 316L stainless steel.

SUMMARY

1. This investigation demonstrated that the 10 per nitric – 3 per cent hydrofluoric acid test can be standardized and successfully used to evaluate the intergranular corrosion resistance of type 316L stainless steel.

2. Initial research on the nitric-hydrofluoric acid test indicated the following:

(*a*) Optimum test conditions consisted of two 2-hr periods in a 10 per cent nitric – 3 per cent hydrofluoric acid solution at 70 C.

(*b*) The high general corrosion rate encountered in a hot 10 per cent nitric – 3 per cent hydrofluoric acid solution required the testing of two samples, one sample in the commercially annealed condition and the other sample in the sensitized condition (1 hr at 1250 F, WQ). A ratio was obtained by dividing the corrosion rate for the sensitized condition by the corrosion rate for the annealed condition. This ratio was used to evaluate the amount of intergranular attack undergone by the sensitized specimen.[15]

3. The reliability of the nitric-hydrofluoric acid test was determined by evaluating eighty commercial heats of types 316 and 316L stainless steel in a 10 per cent nitric – 3 per cent hydrofluoric acid solution at 70 C. Each heat was also evaluated by the electrolytic oxalic acid etching test in order to microstructurally reveal any damaging carbide precipitation. Results of this evaluation are listed below:

(*a*) In the nitric-hydrofluoric acid test, 97 per cent of the type 316L stainless steel heats had ratios of 1.5 or less, indicating satisfactory resistance to intergranular corrosion in the sensitized condition and the absence of damaging carbide precipitation.

(*b*) Results of the electrolytic oxalic acid etching test correlated well with those of the nitric-hydrofluoric acid test. Ninety-four per cent of the type 316L stainless steel heats had step or dual structures (absence of damaging carbide precipitation) when sensitized and subjected to the oxalic acid etching test. All of the heats included in the 94 per cent had ratios of 1.5 or less in the nitric-hydrofluoric acid test. These results show that the electrolytic oxalic acid etching test successfully predicted that 94 per cent of the type 316L heats would have acceptable resistance to intergranular corrosion in the nitric hydrofluoric acid test.

4. The results of this investigation indicate that the following procedure could be used for the selection of type 316L stainless steel having adequate resistance to intergranular corrosion in the as-welded condition.

(*a*) A sample of the steel is sensitized for 1 hr at 1250 F, WQ and then subjected to the electrolytic oxalic acid etching test. A step or dual structure in this test indicates that damaging carbide precipitation is not present and that no further corrosion evaluation is necessary. If the sample shows a ditch structure in the oxalic acid etching test, the steel must be evaluated by the 10 per cent nitric – 3 per cent hydrofluoric test as outlined.

(*b*) Two samples of the steel, one commercially annealed and the other sensitized for 1 hr at 1250 F, WQ, are tested for two 2-hr periods in a 10 per cent nitric – 3 per cent hydrofluoric acid solution at 70 C. If the ratio of the sensitized corrosion rate to the annealed corrosion rate is 1.5 or less, then the steel has acceptable resistance to intergranular corrosion. Type 316L stainless steel having a nitric-hydrofluoric acid test ratio of greater than 1.5 should not be used in the as-welded condition for service involving intergranular corrosion.

Acknowledgments

Particular thanks are due G. T. Vaughn who assisted with the evaluation tests reported in this paper.

[15] A ratio of approximately 1 indicated that the sensitized specimen corroded at the same rate as the annealed specimen and that no intergranular corrosion had occurred.

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Flame Spread Properties of Building Finish Materials

By DANIEL GROSS and JOSEPH J. LOFTUS

IN THE specification of materials for the interior finish of buildings and other structures, the flame-spread behavior of the material may be as important as strength, ease of application, appearance, durability, or other qualities. The previous lack of a simple and relatively inexpensive method of evaluation has delayed the comprehensive study of this fire characteristic of materials. Completion of the development of the radiant panel flame spread test method[1] at the National Bureau of Standards has now made this study possible. Data have been obtained on a wide variety of interior wall finishes applied to several common wall base materials, as well as on other interior and exterior lining materials. The numerical index appears to classify materials in an order generally consistent with information currently available on their behavior during fires. Additional data obtained from full scale and model testing are required to determine the relationship between the radiant panel flame-spread index of a material and the actual fire hazard involved with a structure lined with this material.

Fig. 1.—Radiant panel test apparatus.

Method of Test

The apparatus used for the tests has been described in detail by Robertson, Gross, and Loftus[1] and is shown in Fig. 1. It consists of a radiant panel, a frame for support of the test specimen, and associated measuring equipment.

Briefly, the radiant panel consists of a cast iron frame enclosing a 12 by 18-in. porous refractory material. The panel is mounted in a vertical plane and a premixed gas-air mixture supplied from the rear is burned in intimate contact with the refractory surface, providing a radiant heat source. The energy output of the panel, which is maintained by regulating the gas flow according to the indication of a radiation pyrometer, is that which would be obtained from a black body of the same dimensions operating at a temperature of 670 C. A stack placed under the hood above the test specimen receives the hot products of combustion and smoke.

The test specimen, measuring 6 by 18 in., was placed in a metal holder and backed up with a ½-in. sheet of asbestos

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NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] A. F. Robertson, D. Gross, and J. Loftus, "A Method for Measuring Surface Flammability of Materials Using a Radiant Energy Source," *Proceedings*, Am. Soc. Testing Mats., Vol. 56, pp. 1437–1453 (1956).

millboard of 60 lb per cu ft density. At time zero, the specimen was placed in position on the supporting frame facing the radiant panel and inclined 30 deg to it. Observations were then made of the progress of the flame front, the occurrence of flashes, etc. A pilot igniter fed by an air-acetylene mixture served both to initiate flaming at the upper edge of the test specimen and to ignite combustible gases rising from the specimen. An electrical timer calibrated in minutes and decimal fractions to hundredths was used for recording the time of occurrence of events during the tests. The test duration was 15 min or until sustained flaming had traversed the entire 18-in. length of specimen, whichever time was less.

The flame spread index, I_s, was computed as the product of the flame spread factor, F_s, and the heat evolution, Q, thus:

$$I_s = F_s Q$$

where:

$$F_s = 1 + \frac{1}{t_3} + \frac{1}{t_6 - t_3} + \frac{1}{t_9 - t_6} + \frac{1}{t_{12} - t_9} + \frac{1}{t_{15} - t_{12}},$$

($t_{..}$ . . . . t_{15} correspond to the times in minutes from specimen exposure until arrival of the flame front at a position 3 . . . . 15 in., respectively, along the length of the specimen)

and

$Q = 0.1\Delta\theta/\beta$.

The constant 0.1 was arbitrarily chosen to yield a flame-spread index of approximately 100 for red oak. $\Delta\theta$ is the observed maximum stack thermocouple temperature rise in degrees Fahrenheit over that observed with an asbestos-cement board specimen, and β is the maximum stack thermocouple temperature rise for unit heat input rate to the calibration burner, in units of degrees Fahr per Btu per min.

Materials

The specimens comprised a wide variety of representative finish materials including liquid coatings, films, sheets, panels, and plastics (see Table I). One series of interior finishes was applied to the smooth finished side of three common wall base materials: plywood, fiberboard, and gypsum board. The finish materials were applied to the base material employing standard application materials and methods and following manufacturers' suggestions wherever practical.

The following procedures of specimen preparation were used for the series of plastic materials designated 1 to 12:

1. Opaque (to infrared radiation) materials of greater than $\frac{1}{16}$ in. thickness were not applied to any base material.
2. Opaque materials of $\frac{1}{16}$ in. thickness or less were applied to a $\frac{3}{8}$ or $\frac{1}{2}$-in. thick gypsum board base material (flame-spread index approximately 10 to 20).
3. Transparent or translucent materials of any thickness were not applied to any base material but were backed by a sheet of highly reflective aluminum foil.

The assemblies prepared as indicated were air dried for not less than 72 hr. They were then cut into 6 by 18 in. specimens and placed in a room maintained at 75 F and 50 per cent relative humidity for not less than one week's conditioning prior to testing.

Procedure and Results

Previous work[1] had indicated that variations in specimen structure, such as orientation of grain, pores, laminations, variations in the thickness, and bond of the finish or protective coating may appreciably affect the flame-spread behavior of a material. Data dispersion as indicated by the coefficient of variation had ranged from 5 to over 60 per cent. One phase of this study involved an analysis of part of the data to obtain a statistical measure of the variance assignable to finish material, base material, the constancy of differences among the materials, and a measure of the random errors inherent in the measurements.

To test for the existence of "order within a day" and "day-to-day" effects as well as to estimate the extent of the testing program necessary, a series of tests of eight finish materials on each of four base materials in duplicate was performed in an ordered sequence. Statistical analysis of these preliminary results indicated that variations due to the testing order during the day (that is, whether tested in the morning, noon, or afternoon) and variations due to testing over a period of time (day or weeks) were not significant as compared with variations observed between duplicate specimens. A random testing procedure was therefore adopted for all subsequent tests.

The average flame-spread index values are given in Table II. The weight of the smoke deposit reported is the average for replicate specimens and is based upon at least three determinations except in the instances where a smoke deposit of less than 1.0 mg was obtained in the first two determinations.

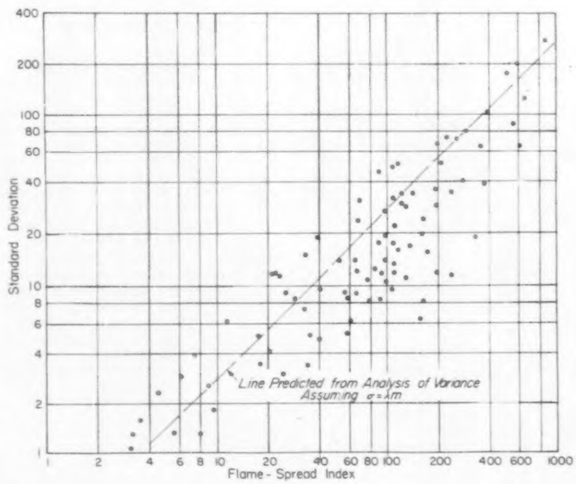

Fig. 2.—Standard deviation as a function of mean flame spread index.

Statistical Analysis

Figure 2 is a plot of the standard deviation as a function of the average flame-spread index for the finish materials tested. These standard deviations are based on four repeat determinations and, bearing in mind the uncertainty of standard deviation estimates based on 3 degrees of freedom, there is the suggestion that the standard deviation is proportional to the mean.

In order to combine the information on reproducibility from such widely varying standard deviations in analysis of variance procedures, it is necessary that all standard deviation estimates be estimates of the same quantity. If it can be assumed that the standard deviation σ, is in fact proportional to the mean, m, say $\sigma = \lambda m$, a logarithmic transformation of the flame-spread values will produce values that have a common standard deviation.[2]

This assumption of the proportionability of standard deviation to the mean appeared to be a satisfactory approximation for these data and the subsequent statistical analyses were carried out in the transformed scale. One thus obtains an estimate (the error term in the analysis of variance) of the proportionality constant λ, by which the variability of a measure-

[2] M. S. Bartlett, "The Use of Transformations," *Biometrics*, Vol. 3, pp. 39–52 (1947).

ment is expressed as a fraction of its mean. This indirect estimate of 0.278, which is the slope of the broken line in Fig. 2, is in fair agreement with the direct estimate, 0.246, of the value of λ based on the untransformed data. Thus a standard deviation of 27.8 per cent of the mean was obtained for individual observations and a standard deviation of 13.9 per cent of the mean ($1/\sqrt{n}$ × standard deviation of individual determination) for averages of four determinations.

In the analysis of variance[3] the differences among the averages for the several materials were compared with the agreement among repeated determinations on the same material. The analysis indicated that (1) for a given base material, there was a considerable difference in the performance of the finish materials, (2) for a given finish material, there was an appreciable difference in performance when applied to the various base materials, and (3) there was a significant difference in performance attributable to the combined effect of finish and base materials.

[3] O. L. Davies, "Design and Analysis of Industrial Experiments," Chapter 4, Oliver and Boyd, London (1954).

TABLE I.—MATERIALS LIST.

Symbol	Material	Description	Thickness, in.	Density, lb per cu ft
		Base Materials		
I........	Plywood	Exterior type Douglas fir grade A-C	¼	39.0
II........	Fiberboard	Building board class D finish	½	19.4
III........	Gypsum board	....	⅜	50.5
		Finish Materials Applied to Base Materials I, II, III		
A.....	Aluminum wall tile	Linked wall tile; 4 in. sq, light green	0.020	161.5
B.....	Enameled wall covering	Enamel baked on felt backing; 4½ in. sq tile design, green with dark green border	0.055	64.9
C.....	Fabric wall covering	Baked enamel on cotton muslin, light green	0.009	80.9
D.....	Wallpaper	Polyvinyl coated, light green	0.008	40.3
E.....	Wallpaper, 5 coats	Embossed paper, light green	0.035	41.8
F.....	Wallpaper, 1 coat	Embossed paper, light green	0.007	41.8
G.....	Wood veneer	Random-grade oak wood veneer on cotton muslin	0.019	54.5
H.....	Cork tile	Standard weight tile, 6 by 12 in., natural color	0.125	30.8
I.....	Wall cloth	Plastic coating on cotton muslin, light green	0.011	70.3
J.....	Burlap	Imported jute fiber, natural color	0.025	30.4
K	Polystyrene	Wall tile, 8¼ in. sq, light green	0.075	65.4
L.....	Plastic-coated wall covering	Clear plastic coating on felt backing, 4¼ in.	0.050	66.9
M.....	Vinyl film	Self-adhesive, knotty pine design	0.004	56.6
N.....	Vinyl counter top	Vinyl surface on felt backing, turquoise	0.070	83.0
O.....	Vinyl counter top	Vinyl surface on felt backing, Caribbean turquoise	0.062	79.8
P.....	Melamine	Baked melamine finish on masonite hardboard plain surface tileboard, April green	0.150	71.8
Q.....	Poly(vinyl chloride)	Transparent film	0.003	69.2
R.....	Melamine	Melamine-surfaced high-pressure laminate on hardboard; linen finish, green	0.150	78.3
T.....	Linoleum tile	Laminated tile, 9 in. sq, marbleized gray	0.125	86.0
U.....	Latex paint	Flat interior finish, dado green, 1 primer coat, 2 paint coats	0.004[a]	86.5[b]
V.....	Alkyd paint	Flat, aqua, 1 primer coat, 2 paint coats	0.003[a]	100.0[b]
W.....	Oleoresinous paint	Flat, white, 1 primer coat, 2 paint coats	0.004[a]	97.5[b]
X.....	Alkyd paint	Gloss, light green, 2 primer coats, 2 paint coats	0.005[a]	77.5[b]
Y.....	Varnish	Interior varnish, clear color, 3 coats	0.004[a]	55.0[b]
Z.....	Shellac	White, 3 coats	0.006[a]	57.6[b]
		Other Materials		
a......	Aluminum foil	Glued to plywood	0.003	41.6[c]
b......	Cellulose-mineral board	....	0.875	47.8
c......	Paint, oil base	On cement asbestos board	0.010	...
d......	Paint, oil base	On steel	0.010	...
e......	Acoustic tile	Mineral base	0.750	19.3
f......	Fire retardant paint	On plywood	0.006	42.3[c]
g......	Red oak	Plain sawed, select grade, 2¼-in. face	0.750	40.0
h......	Acoustic tile	Perforated fiberboard	0.500	16.7
i......	Hardboard	Smooth side exposed	0.218	59.8
j......	Fiberboard	Unfinished	0.500	18.0
		Plastic Materials		
1.....	Rigid poly(vinyl chloride)	Gray	0.147	86.0
2.....	Rigid poly(vinyl chloride)	Retardant treated, dark gray	0.147	88.0
3.....	Phenolic laminate[d]	Dark gray	0.063	76.4
4.....	Linoleum tile[d]	Retardant treated, white and black	0.065	131.0
5.....	Acrylic	Retardant treated, milky white	0.125	75.0
6.....	Polystyrene[d]	Extruded sheet, impact grade, white	0.066	58.2
7.....	Polystyrene tile[d]	4¼ in. sq, cream	0.068	64.6
8.....	Poly(vinyl chloride)[d]	Retardant treated film on cotton, white	0.018	60.4
9.....	Poly(vinyl chloride)[d]	Film on cotton, gray	0.021	74.5
10.....	Glass reinforced polyester	27 per cent glass, translucent	0.085	87.0
11.....	Glass reinforced polyester	27 per cent glass, retardant treated, translucent	0.095	97.6
12.....	Glass reinforced polyester	21 per cent glass, translucent	0.062	81.7

[a] Estimated.
[b] Liquid density.
[c] Bulk density.
[d] Gypsum board base.

Discussion of Results

The base material as well as the surface finish material (and associated application materials) were important factors in the flame-spread behavior of composite test assemblies. While a thick finish material almost completely masked any base material effect, the base material behavior predominated in those test assemblies with thin vinyl, M, or poly (vinyl chloride) Q, films.

Paints U, V, W, and X, and other thin coverings C, F, in the thickness range 0.003 to 0.010 in. considerably reduced the flame spread index obtained with the bare base materials I, II, and III. In the thickness range 0.010 to 0.050 in., higher flame-spread index values were obtained with these finish materials on a fiberboard base than on the other base materials. This may be attributed to the thermal insulating effect of the fiberboard base. The base material had considerably less effect upon the flame-spread index of an assembly in which the finish material thickness was greater than 0.050 in., B, H, K, L, N, O, P, R, T.

Since highly reflective finishes do not absorb as much radiant energy as dull, black surfaces, they spread flame less rapidly. Due to its high reflectance and impermeable char-

TABLE II.—FLAME SPREAD AND SMOKE DEPOSIT DATA.
Effect of Base Material—Average of 4 Tests

Symbol	Finish Material	Plywood Base			Fiberboard Base			Gypsum Board Base		
		Flame-Spread Index	Coefficient of Variation, per cent	Smoke, mg	Flame-Spread Index	Coefficient of Variation, per cent	Smoke, mg	Flame-Spread Index	Coefficient of Variation, per cent	Smoke, mg
Base material		195	15.0	0.8	110	11.9	0.5	22	54.3	0.1
A	Aluminum wall tile	33	22.3	1.7	39	48.8	3.4	6.2	46.8	0.0
B	Enameled wall covering	110	20.1	6.0	116	43.8	4.9	67	35.5	2.1
C	Fabric wall covering	29	29.6	0.5	25	36.2	0.5	3.1	34.5	0.1
D	Wallpaper	98	14.4	0.6	193	18.9	0.2	20	20.5	0.1
E	Wallpaper, 5 coats	61	10.1	0.6	116	13.7	0.5	35	14.3	0.0
F	Wallpaper, 1 coat	64	21.7	0.9	76	14.2	0.2	5.6	23.8	0.0
G	Wood veneer	163	14.8	0.7	197	6.1	0.3	58	14.1	0.4
H	Cork tile	642	19.3	1.5	560	15.8	1.7	610	10.6	1.7
I	Wall cloth	18	19.2	1.9	24	12.2	2.1	4.5	51.2	0.5
J	Burlap	163	5.2	0.0	279	14.6	0.0	108	16.2	0.3
K	Polystyrene	590	33.1	13.7	520	33.9	20.1	335	5.7	17.5
L	Plastic coat wall covering	293	27.4	8.2	394	27.2	8.7	253	28.2	7.0
M	Vinyl film	128	22.4	2.4	144	36.8	2.2	21	55.9	1.1
N	Vinyl counter top	40	12.1	7.7	52	27.5	7.7	34	10.0	8.1
O	Vinyl counter top	121	24.6	7.9	196	34.3	8.3	97	27.9	7.6
P	Melamine	90	19.8	6.4	80	10.4	5.7	57	16.2	4.1
Q	Poly(vinyl chloride)	209	24.5	0.9	109	12.3	0.1	23	46.9	0.0
R	Melamine plastic	92	9.2	3.5	122	28.3	4.7	84	14.9	3.0
T	Linoleum tile	129	8.6	10.1	172	9.4	13.1	106	8.9	8.5
U	Latex paint	93	12.7	1.3	66	18.6	0.4	8.9	28.9	0.3
V	Alkyd paint flat	69	45.4	0.4	40	23.8	0.2	0.8	25.3	0.0
W	Oleoresinous paint	58	9.0	1.0	18	28.9	0.4	3.5	44.5	0.0
X	Alkyd paint gloss	97	20.0	1.7	108	29.7	0.5	8.0	16.3	0.6
Y	Varnish	162	12.2	0.6	...	...	...	...	...	...
Z	Shellac	832	35.3	0.2	...	...	...	...	...	...

Symbol	Material	Number of Tests	Flame-Spread Index	Coefficient of Variation, per cent	Smoke, mg
	OTHER MATERIALS				
a	Aluminum foil on plywood	4	1.0	73.3	0.1
b	Cellulose mineral board	5	1.3	38.5	0.2
c	Paint on cement asbestos board	5	2.0	29.0	0.0
d	Paint on steel	5	7.4	51.9	0.0
e	Acoustic tile, mineral base	5	11.5	54.0	0.0
f	Fire retardant paint on plywood	6	33	45.4	1.2
g	Red oak	5	99	10.7	0.3
h	Acoustic tile, fiberboard	5	116	13.6	0.3
i	Hardboard	5	136	12.4	4.1
j	Fiberboard, unfinished	9	236	5.0	0.2
	PLASTIC MATERIALS				
1	Rigid poly(vinyl chloride)	4	9.6	18.2	28.9
2	Rigid poly(vinyl chloride) treated	4	3.2	40.0	10.5
3	Phenolic laminate	5	107	45.3	1.1
4	Linoleum tile	4	2.1	39.9	15.2
5	Acrylic treated	4	376	10.3	40.6
6	Polystyrene extruded	4	355	18.3	23.0
7	Polystyrene tile[a]	4	224	32.7	10.6
8	Poly(vinyl chloride) treated	5	4.5	57.6	1.1
9	Poly(vinyl chloride)	5	89	51.1	3.9
10	Glass 27 per cent reinforced polyester	3	154	4.2	18.4
11	Glass reinforced polyester treated	4	66	13.7	22.3
12	Glass 21 per cent reinforced polyester	3	239	14.6	15.9

[a] Specimen supported by metal strip to prevent dropping.

acter, a thin (0.003-in.) sheet of aluminum foil provided an unbroken protective surface and reduced the flame-spread index of plywood to 1.0.

The flame-spread indices of the plastics group tested ranged from below 10 for representative polyvinyl materials to over 200 for polystyrene and acrylic type plastics. The poly(vinyl chloride) films on cotton exhibited flashing tendencies.

It can be seen from Table II that the flame spread indices for most finish materials on gypsum board were significantly lower than on the other base materials, with the index for finish materials on fiberboard generally the highest. One measure of the effect of base material is given by the ratio of the flame-spread index for a given finish material as applied to two different base materials. The correlation with finish material thickness when applied to fiberboard and gypsum board base materials is evident from Fig. 3.

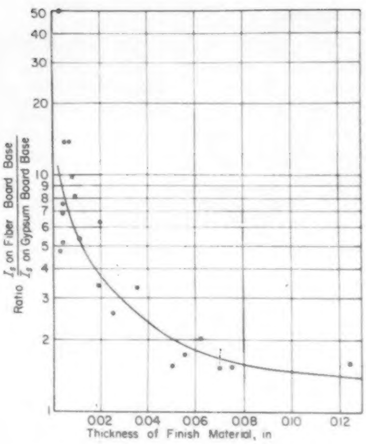

Fig. 3.—Effect of finish material thickness upon flame spread index ratio for two base materials.

Smoke measurements furnish an indication of the interference to be expected in fire-fighting or evacuation procedures during a fire rather than of fire intensity or rapidity of flame spread. A smoke deposit of 1.0 mg or less was generally obtained with materials which did not evolve appreciable quantities of smoke according to visual observations. Over half the assemblies tested evolved less than 1.0 mg of smoke deposit. It was observed that finish materials on a fiberboard base generally produced greater smoke deposits than the same finish materials on plywood or gypsum board bases. Polystyrene tile K, evolved a very heavy quantity of sooty smoke, and considerable smoke was also produced by linoleum tile, T, plastic-coated wall covering L, the vinyl counter top materials, N, O, and nearly all the plastic materials.

It should be emphasized that the method of test measures the flame-spread properties of the exposed surface of the test assembly only. Where assemblies of this type are used for application directly to studs or over other enclosed open spaces, it appears highly desirable to consider the flame-spread properties of the interior stud space lining as well.

Summary

Flame-spread data, as measured by the radiant panel method, have been obtained for a wide variety of materials including representative composite assemblies of interior finishes applied to common wall base materials. The base material as well as the surface finish material are important factors in the flame-spread behavior of a composite assembly. For the materials tested, the effect of the base material upon the flame-spread index of an assembly decreases as the finish material thickness increases. The standard deviation of a single observation was found to be approximately 27.8 per cent of the mean flame-spread index for many materials but considerable variation was observed.

Acknowledgment:

The authors acknowledge the valuable contribution of J. M. Cameron, Statistical Engineering Section, whose statistical analysis of the test results aided considerably in its interpretation.

Services That Enrich*

TECHNICAL societies are so much a part of our technological culture that they are sometimes taken for granted. People know that technical societies perform worth-while services, yet the public at large has but a vague idea of what these services are. Even scientists and engineers may have limited perspective on the roles of technical societies in furthering scientific and industrial progress.

The main objective of the technical society is usually to promote the field of science, technology or engineering with which it is associated. This is accomplished through the sponsorship of publications, meetings, lectures, symposia, expositions, awards, and group attack on technical problems. Other objectives are the furthering of recognition of the professional status of members, the encouragement of industry in the area of technical endeavor, and the formulation of engineering standards.

Technical societies, by providing platforms on which ideas are discussed and weighed, are safeguards for truth and scientific integrity. They keep technical people from veering off the path, and they are bulwarks against external threats to scientific thinking and procedure. At the same time, technical organizations serve as focal points around which schools of new thought can rally and find expression. These schools of thought, just as those of artists and musicians, stimulate creativity.

Technical societies encourage a fraternal type of spirit among members. This feeling of kinship facilitates the interchange of ideas and provides the underlying foundation for fruitful friendships and constructive competition. Unanimity in the devotion of technical people to great public causes is frequently solidified at the annual meetings of technical societies.

And, of course, technical societies are a boon to research. Their mechanisms for communication are the traditional mechanisms used by research people for the interchange of knowledge. Their publications are records of research experience, effort, and thought. The abstract services, bibliographies, and indexes they provide are tools used in nearly all creative investigations. The studies sponsored directly by technical society committees fill important gaps in knowledge and hasten the application of science to the solution of human problems. Without these services, research could not possibly have made the great contribution to human welfare it has in recent decades.

CLYDE WILLIAMS
President, Battelle Memorial Institute

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Small Tunnel-Furnace Test for

Measuring Surface Flammability

By H. D. BRUCE and V. P. MINIUTTI

THE RATE at which flame spreads over combustible surfaces inside a building controls the rapidity with which small unattended fires will grow beyond possibility of suppression or of escape by occupants. The flammability of the contents of the building is important if the contents or furnishings are afire; likewise, the flammability of the surface coverings of the walls is important if the fire is on or adjacent to the walls. Combustible wall-surface materials lend additional fire hazard to buildings in which they may be used, and because they are subject to control by the builder and building regulations, their fire properties have been given increased attention during recent years (**1**—**5**).[1] Of particular importance are the spread-of-flame characteristics of wallboards evaluated in terms commensurate with fire hazard.

In 1950, the ASTM published method E 84–50 T[2] as a tentative method of classifying building materials as to fire hazard. The tentative standard was written to describe the procedure employed by the Underwriters' Laboratories (UL) with their large tunnel furnace in Chicago (**6**).[3] At the time method E 84 was recommended as a tentative standard, the Forest Products Laboratory had received support from the Housing and Home Finance Agency for the development of a tunnel test, such as ASTM Committee E-5 on Fire Tests of Materials and Construction was interested in, to measure rates of flame spread on combustible building materials. The committee's report stated that "further study and research now under way may result in a reduction in the size of equipment needed and the costs of making tests." In September, 1953, at the request of Committee E-5, ASTM entered into a cooperative agreement with the Forest Products Laboratory to continue development of the small tunnel.[4] The purpose of the work was to evolve a tunnel furnace small enough to encourage construction of several such furnaces, and thereby make possible comparison of test results, but capable of giving a practical and significant fire-hazard classification of building materials.

Construction and Operation

A furnace taking a narrow specimen 8 ft long was first built, modeled after the UL tunnel. It was soon found that the position of the flame front on the horizontal specimen was too indefinite to permit precise evaluation of the flame-spread rate on a short specimen. The difficulty was overcome by tilting the specimen so that the progress would be measured, not of the flickering evanescent tips of the flame pattern, but of the much more regular and definite side of the pattern (Fig. 1) where the flame is steady.[5] The FPL small tunnel furnace in its final form is shown in Figs. 2 to 6.

The body of the furnace is constructed of 12-gage, hot-rolled, low-carbon steel, lined with 1 in. of high grade asbestos millboard bonded to the sheet metal with a room-temperature-curing, epoxy-resin adhesive. The furnace has essentially three compartments: the firebox (*2*, Fig. 2); the specimen combustion chamber (above the plate *5*, Fig. 3); and the collecting hood and stack (*6*, Fig. 2). Between the firebox and the combustion chamber is a 12-gage, type-310, stainless steel partition in which are 36 holes $1\frac{19}{32}$ in. in diameter spaced $2\frac{9}{16}$ in. apart, center to center. In the holes are set Meker burner

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NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

[2] Tentative Method of Fire Hazard Classification of Building Materials (E 84 – 50 T) 1955 Book of ASTM Standards, Part 4, p. 1204.

[3] The Underwriters' Laboratories tunnel furnace in Chicago was long the only one in existence, but recently two more large tunnel furnaces have been constructed, one in Canada and one in Texas.

[4] The work was supported in part by funds contributed by industry under the sponsorship of the ASTM.

[5] In The Underwriters' Laboratories tunnel the flame front is not considered to be at the flame tips but where the sheet of flame is first continuous over the width of the specimen.

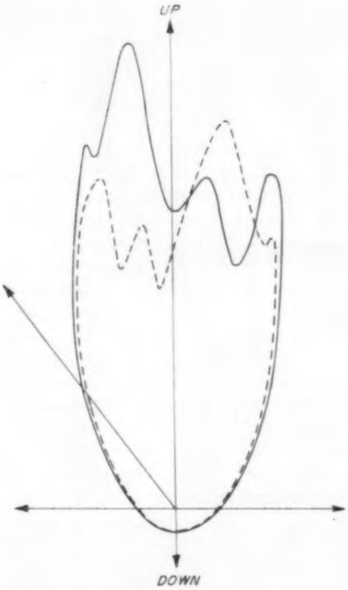

Fig. 1.—Generalized fire pattern on a flat combustible face. From point of ignition, +, flames spread at different rates in different directions. Dotted line shows possible position of flames at one instant; solid line shows position flames might have an instant later.

Fig. 2.—Specimen side of FPL small tunnel furnace. *1*, gas supply to main burner; *2*, firebox; *3*, clamp to hold down cover over test specimen; *4*, gas supply to igniting burner; *5*, cover over test specimen; *6*, hood to collect combustion gases for temperature and smoke measurement; and *7*, photoelectric cell for smoke-density measurement.

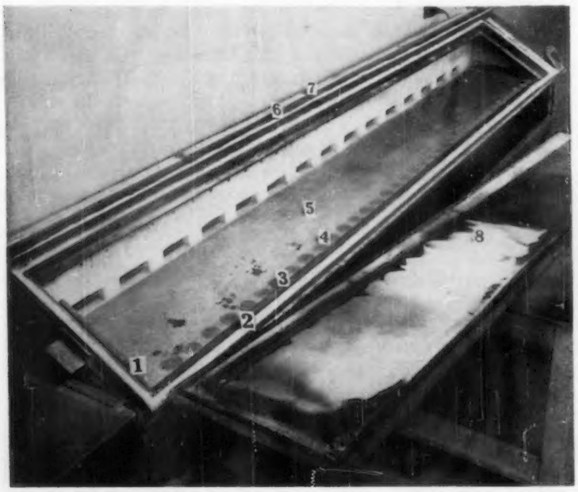

Fig. 3.—Specimen combustion chamber of FPL tunnel furnace. *1*, igniting burner; *2*, sand trough to seal cover; *3*, angle-iron bed on which specimen rests; *4*, holes in hot plate inset with Meker burner tops; *5*, hot plate over firebox; *6*, sand trough to seal edge of hood; *7*, slot for escape of combustion gases; and *8*, specimen cover.

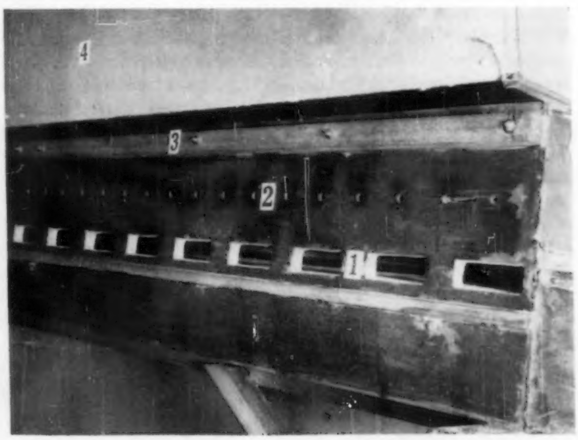

Fig. 4.—Observer side of FPL tunnel furnace. *1*, fresh-air ports; *2*, observation holes; *3*, hollow steel bar to stiffen tunnel wall; *4*, hood to collect combustion gases for temperature and smoke measurements.

tops (*4*, Fig. 3). To control the flow of combustion gases up through the holes, it was found desirable to graduate the size of the holes with washers of $\frac{1}{32}$-in. asbestos paper in the Meker burner tops from full size at the fire end to fully closed at the flue end. The sizes of the holes are as follows:

Hole	
Nos. 1 to 13	$^{23}/_{16}$ in.
Nos. 14, 15	$^{16}/_{16}$ in.
Nos. 16, 17	$^{14}/_{16}$ in.
Nos. 18, 19	$^{13}/_{16}$ in.
Nos. 20, 21	$^{12}/_{16}$ in.
Nos. 22, 23	$^{11}/_{16}$ in.
Nos. 24, 25	$^{10}/_{16}$ in.
Nos. 26, 27	$^{9}/_{16}$ in.
Nos. 28, 29	$^{8}/_{16}$ in.
Nos. 30, 31	$^{7}/_{16}$ in.
Nos. 32, 33	$^{6}/_{16}$ in.
Nos. 34-36	Closed

The hood and stack (*6*, Fig. 2) are of 16-gage, hot-rolled, low-carbon steel insulated with $\frac{1}{4}$-in.-thick asbestos millboard glued on with an epoxy resin. (Mechanical drawings of the furnace are available from the Forest Products Laboratory, Madison, Wis., upon request.)

The test specimen, $13\frac{3}{4}$ in. wide by 8 ft. long,[6] is laid on an angle-iron frame (*3*, Fig. 3) tilted 30 deg from the horizontal.

The construction and operation of the furnace were simplified by sloping the tunnel at a 6 deg angle from end to end to allow natural convection of air and combustion gases, and to avoid the need for draft control.

The main burner (Fig. 5) is a $1\frac{1}{4}$-in. T-head iron pipe in which are drilled two parallel rows of holes 90 deg apart. Each row has 53 holes $\frac{1}{8}$ in. in diameter with centers $\frac{1}{4}$ in. apart.[7] The burner is located in the firebox with the holes 13 in. from the front end. Gas is burned at the rate of 3400 Btu per min with a supply of primary air adequate to produce a blue flame, introduced by an atmospheric injector air-gas mixing unit (Fig. 5). The natural gas supplied to the Forest Products Laboratory varies somewhat in composition and heat content from day to day. Before each test, the current heat value of the gas in Btu per cu ft under selected conditions of temperature and pressure is obtained from the gas company. The temperature and pressure of the gas as it is fed into the main burner are also measured and used to compute the volume rate of flow for 3400 Btu per min in the firebox by the formula:

$$V = \frac{P_1 T_2\,3400}{P_2 T_1 H}$$

where: V is the desired rate of gas flow in cubic feet per minute under conditions of use for 3400 Btu per min., T_2 is the absolute temperature of the gas as used, deg Kelvin, P_2 is the absolute pressure of the gas as used in mm of mercury (barometer pressure plus gage pressure), and H is the heat content of the gas, Btu per cu ft, under given con ditions of P_1 mm of mercury and T_1 deg Kelvin.

The igniting burner (*1*, Fig. 3) is a $\frac{1}{4}$-in. iron pipe in which are six $\frac{1}{8}$-in.-diameter holes with centers 1 in. apart. It is located $\frac{1}{2}$ in. below and parallel to the face of the test panel and 1 in. from the end. Gas is burned with no primary air at the rate of 85 Btu per min. The individual flames from the orifices in this burner play over the first 4 in. of an asbestos board specimen. Both burners are lighted as simultaneously as possible, and stop watches are started at the instant of lighting.

The specimen is heated by radiant energy from the hot partition over the firebox and by combustion gases rising through the holes in the partition from the firebox into the specimen combustion chamber. Fresh air enters the combustion cham-

Fig. 5.—T-head main burner and atmospheric injector air-gas mixing unit.

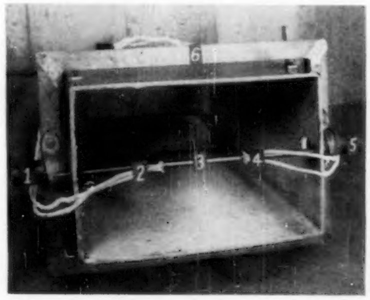

Fig. 6—View down stack of hood. *1*, *5*, pipes for mounting photo-electric cell and light source; *2*, *4*, thermocouples embedded in copper rod; *3*, ½-in. copper rod; *6*, angle-iron frame attached to stack corners to support smoke meter.

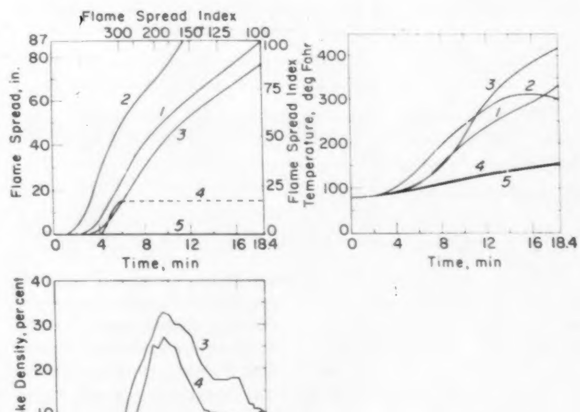

Fig. 7.—Typical curves of tunnel data from tests on, *1*, Red oak; *2*, Fiberboard A; *3*, Hardboard M_1; *4*, Gypsum wallboard G; and *5*, Asbestos millboard.

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[6] Three specimens can be cut from a sheet 4 ft wide and 8 ft long, with extra material for moisture content determination and miscellaneous tests.

[7] This burner was found suitable for natural gas. For bottled and manufactured gases, the burner construction may have to be altered.

ber through the rectangular ports (*1*, Fig. 4), and flows across the hot partition and up the face of the specimen. Combustion starts at the igniting burner, and flame travels over the surface of the combustible test specimen from right to left as the operator watches the progress through the observation holes (*2*, Fig. 4) with the line of sight toward the centerline of the specimen. As the flame front passes each observation hole, the operator notes the time and the distance traveled.

The combustion gases from the burning specimen pass into the hood and up the stack, where their temperature and smoke density are measured. For the temperature measurement, two thermocouple junctions are embedded in a copper rod $\frac{1}{2}$ in. in diameter and $17\frac{1}{8}$ in. in length, which is held horizontally in the stack (*3*, Fig. 6). Temperatures are indicated by a direct-reading potentiometer. Smoke density is determined with a smoke meter, which indicates percentagewise the reduction in the intensity of a column of light passing horizontallly through the stack to a photoelectric cell. Temperatures and smoke densities are noted by the operator every 30 sec. The observations are plotted in graphs as shown in Fig. 7. The maximum length of travel of the flame on the specimen is taken to be 87 in.[8] The average time for the flame to travel this distance on red oak of medium density was 18.4 min, and this period was taken as the test duration.[9]

The flame spread is expressed as an index relative to the rate on red oak with an index of 100 and on asbestos board with an index of 0, following the procedure employed by the Underwriters' Laboratories. This procedure is illustrated in Fig. 7 in which the index units are on the top horizontal and right vertical axes. It will be noted from Fig. 7, upper left, that the flame-spread index value is expressed in either of two ways, depending on whether the flame reached the end of the test specimen in shorter or longer time than on red oak.

For flame spread faster than on red oak,

$$\text{Flame-Spread Index} = 100\,\frac{\text{time to reach end of red oak specimen}}{\text{time to reach end of test specimen}}$$

For flame spread slower than on red oak,

$$\text{Flame-Spread Index} = 100\,\frac{\text{distance reached on test specimen in 18.4 min}}{\text{distance reached on red oak in 18.4 min}}$$

The fuel-contributed index is obtained by measuring by means of a planimeter the areas under the curves indicated in Fig. 7, upper right, and calculating the index value as follows:

$$\text{Fuel contributed index} = 100\,\frac{\text{area under specimen curve} - \text{area under asbestos curve}}{\text{area under red oak curve} - \text{area under asbestos curve}}$$

The smoke-density index is obtained by planimetering the curves indicated in Fig. 7, lower curve, and calculating the index value as follows:

$$\text{Smoke-density index} = 100\,\frac{\text{area under specimen curve} - \text{area under asbestos curve}}{\text{area under red oak curve} - \text{area under asbestos curve}}$$

It was found that the rate at which flame spreads on red oak is dependent on the density of the oak. For red oak to be a suitable standard, therefore, material of a given density had to be selected. For these tests of miscellaneous materials, therefore, plain-sawed, select-grade red-oak flooring, ranging in density between 37.0 and 41.0 lb per cu ft, was chosen for the comparison standard.

[8] The exposed length of the specimen is 94 ½ in. The igniting flame plays over the first 4 in. The end point is taken 91 in. from the first exposed part of the specimen or 87 in. from the igniting flame. The last 3 ½ exposed inches of specimen are disregarded.

[9] This procedure differs from the UL procedure, in which the test duration is several minutes longer than the time for flames to spread the full length of the red oak specimen.

Typical Results and Reproducibility

Typical results obtained with the small tunnel furnace at the Forest Products Laboratory and the described procedure are shown in Fig. 7.

Reproducibility of results is a necessary feature of any test method, but is always limited by uncontrolled variability of the equipment, procedure, and test materials. To learn how the natural variability of the test procedure may affect reproducibility, two or three specimens of 15 materials were tested in the tunnel furnace with a degree of control over the variables moderate enough to be easily obtained in most laboratories. The results are given in Table I. They indicate that the reproducibility by the one furnace is adequate for the nature of the test. How results by several such tunnel furnaces, built to the same specifications, may agree can be answered only after several have been built and compared.

Effects of Operating Variations

Experiments were carried out with a fiberboard, a hardboard, and a gypsum wallboard to ascertain how critical are certain conditions which may be varied in the construction and operation of the Forest Products Laboratory tunnel furnace. In a series of replicate tests on the hardboard, it was found that the hardboard in stock has a flame-spread index of nearly 100 (it averaged 97) and was more uniform than available red oak. Because specimens of hardboard were cheaper and easier to prepare than panels of red oak, the hardboard was used both as a test material and as the comparison standard in most of these experiments on operating variations.

Heat in Firebox

After considerable experimentation with gas combustion rates in the firebox ranging from 2500 to 6000 Btu per min, a rate of 3400 Btu per min was chosen as the preferred standard

TABLE I.—TEST RESULTS OBTAINED WITH THE FOREST PRODUCTS LABORATORY SMALL TUNNEL FURNACE ON MISCELLANEOUS MATERIALS.

Test Material	Flame-Spread Index	Heat-Contributed Index	Smoke-Density Index
Asbestos millboard	0	0	−28
	0	0	29
Red oak flooring	102	102	104
	98	98	96
Fiberboard A, wood fiber	153	138	41
	163	138	47
Fiberboard C, bagasse fiber	135	57	52
	145	59	94
Fiberboard F, mill-applied fire retardant coating	66	31	159
	103	40	146
	62	40	166
Hardboard M_1	89	145	562
	89	141	513
Hardboard M_2	96	126	388
	97	126	350
	98	127	351
Gypsum wallboard G	15	0	356
	17	0	342
	21	0	304
Yellow-poplar lumber	121	120	122
	128	129	187
Redwood lumber	120	64	170
	122	72	206
Exterior Douglas-fir plywood	114	107	140
	112	100	166
Exterior Douglas-fir plywood impregnated with fire retardant	17	3	543
	21	2	427
Exterior Douglas-fir plywood coated with fire retardant	79	37	1000
	84	39	1000
Glass fiber insulation	0	1	181
	0	1	179
Glass fiber reinforced plastic	52	15	2155
	48	13	2225

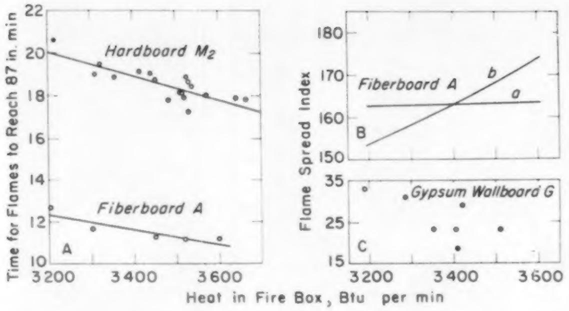


Fig. 8.—Effect of heat in the fire box on: (*A*) time for flames to reach 87 in.; (*B*) flame-spread index of fiberboard A relative to hardboard M_2 with a flame spread index of 100, obtained with (*a*) the same Btu rate for both materials and (*b*) 3400 Btu per minute for hardboard M_2 but various Btu rates for fiberboard A; and (*C*) flame-spread index of gypsum wallboard G based on maximum spread in 18.4 min.

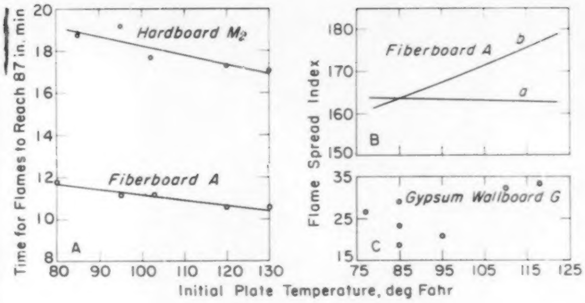


Fig. 9.—Effect of the initial plate temperature on: (*A*) time for flames to reach 87 in.; (*B*) flame-spread index of fiberboard A relative to hardboard M_2 with a flame-spread index of 100 obtained with (*a*), the same plate temperature for both materials and (*b*) a plate temperature of 85 F for hardboard M_2 and various plate temperatures for fiberboard A; and (*C*) flame-spread index of gypsum wallboard G based on maximum spread in 18.4 min.

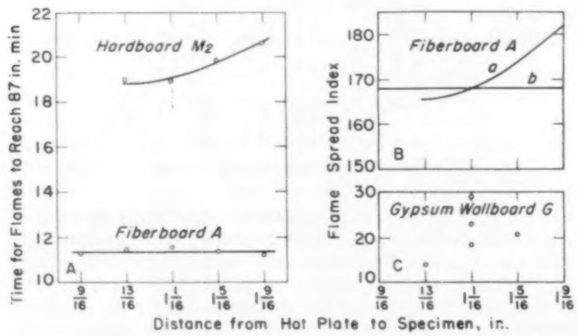


Fig. 10.—Effect of the distance from hot plate to specimen on: (*A*) time for flames to reach 87 in.; (*B*) flame-spread index of fiberboard A relative to hardboard M_2 with a flame-spread index of 100 obtained with (*a*) the same distance for both materials and (*b*) $1\frac{1}{16}$ in. for hardboard M_2 and various distances for fiberboard A; and (*C*) flame-spread index of gypsum wallboard G based on maximum spread in 18.4 min.

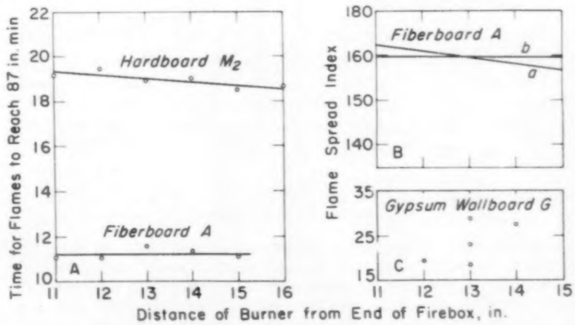


Fig. 11.—Effect of distance from burner to end of fire box on: (*A*) time for flames to reach 87 in.; (*B*) flame-spread index of fiberboard A relative to hardboard M_2 with a flame-spread index of 100 obtained with (*a*) the same distance for both materials and (*b*) 13 in. for hardboard M_2 and various distances for fiberboard A; (*C*) flame-spread index of gypsum wallboard G based on maximum spread in 18.4 in.

operating condition. To learn the magnitude of the error that would result if the combustion rate differed from this standard value, tests were carried out with various gas rates within the range of 3200 to 3700 Btu per min. The flame-spread results are shown in Fig. 8. As expected, the greater the gas combustion rate, the faster was the rate of flame spread for the fiberboard and hardboard.

Initial Plate Temperature

In making tunnel-furnace tests, it is desirable to start with the apparatus always at the same initial temperature, which should be fairly high to save time in cooling the furnace between runs and avoid the possibility of its being often exceeded by the air temperature in summer. These considerations guided the choice of 85 F for the initial temperature of the plate. To learn the effect of initial temperature, experiments were made with initial plate temperatures from 77 to 130 F. The results are shown in Fig. 9. For the fiberboard and hard-board, the higher initial temperatures created faster rates of flame spread, as would be expected.

Distance of Specimen from Hot Plate

The Forest Products Laboratory tunnel was arbitrarily constructed so that the hot plate was $1\frac{1}{16}$ in. from the nearest exposed part of the test specimen. To learn the effect of varying this distance, experiments were made with distances from specimen to plate in the range $\frac{9}{16}$ to $1\frac{9}{16}$ in. The data are given in Fig. 10. The distance from specimen to plate, within the range tested, had little effect on the rate of flame spread on the fiberboard, but appreciably affected the rate on the hardboard.

Position of Burner in Firebox

As a standard condition, the main burner is set 13 in. inside the firebox, with the top of the pipe $1\frac{3}{4}$ in. below the hot plate. Tests were made, however, with the burner set inside the firebox at distances varying from 11 to 16 in. The results are given in Fig. 11. The position of the burner within this range had some effect on the rate of flame spread on the hardboard but little on the rate on the fiberboard.

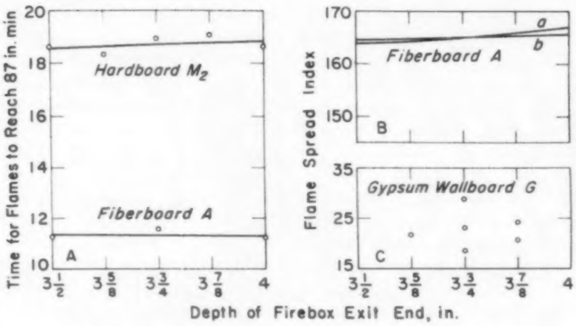


Fig. 12.—Effect of depth of fire box exit end on: (*A*) time for flames to reach 87 in.; (*B*) flame-spread index of fiberboard A relative to hardboard M_2 with a flame-spread index of 100 obtained with (*a*) the same depth for both materials and (*b*) 3¼ in. for hardboard M_2 and various depths for fiberboard A; (*C*) flame-spread index of gypsum wallboard G based on maximum spread in 18.4 min.

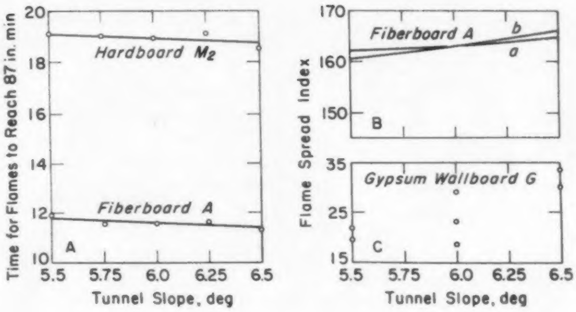


Fig. 13.—Effect of tunnel slope on: (*A*) time for flames to reach 87 in.; (*B*) flame-spread index of fiberboard A relative to hardboard M_2 with a flame-spread index of 100 obtained with (*a*) the same slope for both materials and (*b*) 6 deg for hardboard M_2 and varying slope for fiberboard A; (*C*) flame-spread index of gypsum wallboard G based on maximum spread in 18.4 min.

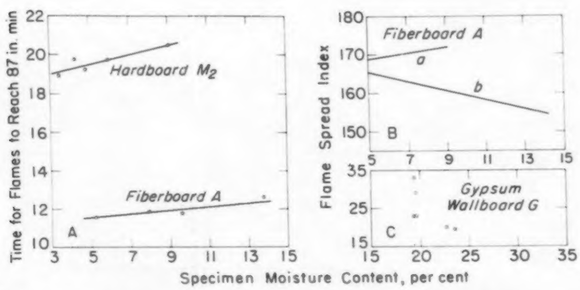


Fig. 14.—Effect of specimen moisture content on: (*A*) time for flames to reach 87 in.; (*B*) flame-spread index of fiberboard A relative to hardboard M_2 with a flame-spread index of 100 obtained with (*a*) the same moisture content for both materials and (*b*) 3½ per cent moisture content for hardboard M_2 and varying moisture contents for fiberboard A; (*C*) flame-spread index for gypsum wallboard G based on maximum spread in 18.4 min.

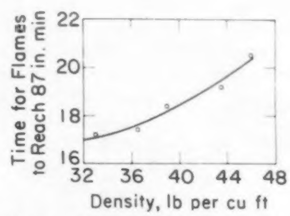


Fig. 15.—Effect of red oak density on flame spread.

Depth of Firebox Exit End

To control the flow of combustion gases from the firebox up through the holes in the hot plate onto the specimen, the exit end of the firebox is partially blocked off. A series of preliminary experiments indicated that a depth of $3\frac{3}{4}$ in. for the exit was suitable. To ascertain the effect of minor variations from this chosen value, tests were made with firebox exits ranging from $3\frac{1}{2}$ to 4 in. in depth (Fig. 12). Within this range, the depth of the firebox exit had a slight effect on the hardboard flame-spread rate but appeared to have less effect on the fiberboard flame-spread rate.

Slope of Tunnel

The slope of the tunnel was arbitrarily fixed at 6 deg after considerable experimentation. Although it is not difficult to maintain the slope at 6 deg it was desirable to learn the effect of slight changes in slope on spread of flame. The results of experiments with the small tunnel at slopes from 5.5 to 6.5 deg are given in Fig. 13. The flame-spread rate was increased on both the fiberboard and hardboard by an increase in slope.

Moisture Content of Specimen

Before testing in the Forest Products Laboratory's small tunnel, it has been the practice to condition specimens to moisture equilibrium in a room at 30 per cent relative humidity and 80 F. Under these conditions the hardboard M_2 came to equilibrium at 3.5 per cent moisture content and the fiberboard A at 5.2 per cent. Tests were made on the wallboards at other moisture contents, also, and the results are given in Fig. 14.

As expected, the higher the moisture content, the lower the rate of flame spread. The effect of moisture was greater for the hardboard than for the fiberboard.

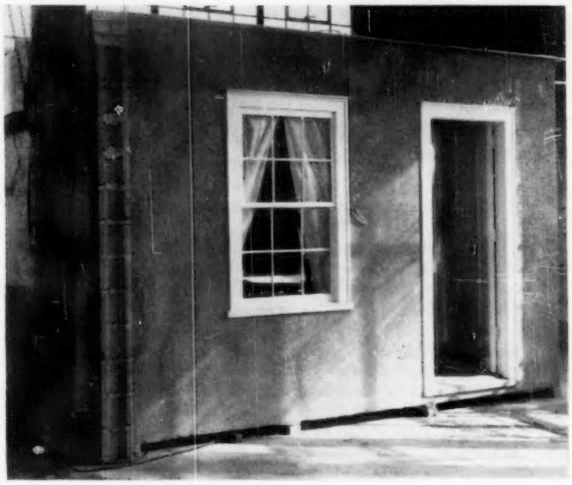
Density of Red-Oak Wood

Air-dried red-oak lumber normally may vary in density from about 32 to 46 lb per cu ft. To learn the effect of density upon the rate of flame-spread and the need for selecting red-oak wood of a given density as a standard, a shipment of red-oak flooring boards was divided into five density classes and each class was tested in the small tunnel. The results, given in Fig. 15, show that the higher the density of the red-oak wood the slower the rate at which flame spreads over the surface, and that the change in flame-spread rate with changes in density was great enough to make selection of the wood within fairly narrow density limits important for a comparison standard.

Discussion

The effects of small variations in operating conditions on the flame-spread index of fiberboard A relative to hardboard M_2 with an assumed index of 100, depends on whether the hardboard was tested under the standard condition or under the same condition as the fiberboard. The magnitudes of the effects are summarized in Table II.

Gypsum wallboard appeared to behave somewhat erratically in the small tunnel because the paper face was on the verge of burning or not burning under the furnace conditions. The flame-spread index values on individual specimens of gypsum wallboard G, relative to the hardboard with an assumed index of 100, lay within the range of 14 to 31, but were too scattered to show the effects of the operating variables without more tests than were made in these experiments.



Interior view showing location of wall and ceiling test panels and igniting wood-crib.

Fig. 16.—Room used for corner wall flame-spread tests.

Comparison of Flame Spread in the Tunnel and in a Room

To characterize combustible materials as to surface flammability, a laboratory method subject to precise control is needed, but the results must have practical significance. To ascertain the practicality of the tunnel-furnace method described in this report, 11 of the materials tested in the small tunnel were applied as coverings to portions of the walls and ceiling of the experimental room shown in Fig. 16 and tested for their effect on the growth of fire in the room. The floor dimensions of the room were 8 by 12 ft and the ceiling height was 8 ft. There was an ample port near the floor for fresh air, and there were two flue vents near the ceiling. The walls and ceiling were partially covered with the material to be tested as shown in Fig. 16.

An initiating fire was set in the paneled corner of the room with a crib built of 20 hard maple sticks, $\frac{7}{8}$ by $\frac{7}{8}$ by 12 in. in size, conditioned to 6 to 7 per cent moisture content, and weighing 2245 ± 2 g. Beneath the crib was a pan containing 50 ml of 95 per cent ethyl alcohol. The alcohol was lighted with a match and the crib sticks soon caught fire. The flames from the crib rose to 3 ft in about 2 min, and against an asbestos wallboard, to a maximum of $5\frac{1}{2}$ ft in about $5\frac{1}{2}$ min. These crib fires were found to be reproducible and satisfactory as an incendiary source.

The following data were recorded: the time required to ignite the wall after the alcohol was lighted, the time at which the flame reached the ceiling, the time at which the ceiling ignited, the time at which the flames reached the flues, whether the flame ever reached the flues, and the maximum distance reached on the wall or ceiling.

These wall-corner fires were realistic. The incendiary crib fire simulated a furniture fire of medium intensity. After a combustible wallboard ignited, the fire hazard increased rapidly. When the flames were on the wall, the fire could be ex-

TABLE II.—EFFECTS OF SMALL VARIATIONS IN OPERATING CONDITIONS ON THE FLAME-SPREAD INDEX OF TWO MATERIALS.

Condition Varied	Range of Variation	Variation in Condition to Change Flame-Spread Index of Fiberboard A, Relative to Hardboard M_2, by 1 Unit	
		Both Tested Under Same Conditions	Fiberboard A Tested Under Various Conditions, M_2 Under Standard Conditions
Heat in firebox	3200 to 3600 Btu per min	500 Btu per min	20 Btu per min
Initial plate temperature.	80 to 130 F	37 deg	2.5 deg
Distance from hot plate to specimen...	$^{13}/_{16}$ to $^{25}/_{16}$ in.	0.045 in.	Over 1 in.
Distance of burner from end of firebox........	11 to 15 in.	0.77 in.	Over 4 in.
Depth of firebox exit end	3½ to 4 in.	0.167 in.	0.50 in.
Tunnel slope..	5½ to 6½ deg	0.40 deg	0.18 deg
Moisture content of specimen........	5 to 14 per cent	1.33 per cent	0.83 per cent

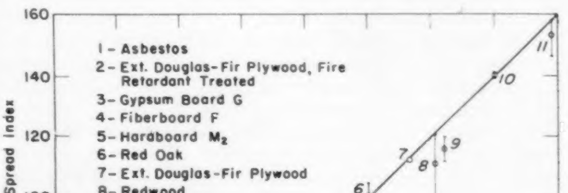


Fig. 17.—Comparison of flame-spread indexes from the FPL tunnel furnace and corner-wall fire tests.

tinguished by water applied from a kitchen utensil. After the ceiling was ignited, the fire could be extinguished with a tank fire extinguisher or garden hose, but probably not by water hand-applied with a dipper or saucepan. By the time the flames reached the flues, a large part of the wall-corner and ceiling panels were covered with flame, the radiation was almost too intense for a human occupant in the room, and despite the flues in the upper reaches of two walls, a layer of hot, choking gas and fumes had collected in the upper part of the room. The difficulty of extinguishing the fire was related to the height of the flames, and the period from outbreak of the fire until flames reached the flues would limit the time available to detect the fire, muster fire-fighting facilities, and allow occupants to escape. Thus, the successive stages of these wall-corner room fires were, in a qualitative way, periods of increasing fire hazard, and correlation of tunnel flame-spread rates with wall-corner flame-spread rates may reasonably be considered to correlate with fire hazard due to flame spread.[10]

Flame-spread indices were calculated from the wall-corner observations in much the same manner as were the indices for the tunnel furnace, as follows: In case the flames reached the flue:

$$\text{Flame-spread index} = \frac{100 \times \text{time for flame to reach flue on red-oak paneling}}{\text{time for flame to reach flue on test wallboard}}$$

In case the flames did not reach the flue:

$$\text{Flame-spread index} = \frac{100 \times \text{maximum distance in excess of 5.5 ft reached by flame on test wallboard in 5.23 min}}{7.5}$$

where 5.5 ft is the maximum distance reached by flames on asbestos wallboard; 7.5 ft is the distance from the 5.5 ft height on the wall to the flues; and 5.23 min is the time from ignition of the alcohol for flame to travel to the flue on red-oak paneling.

The index values calculated for the wall-corner fires in this way are plotted in Fig. 17 against the flame-spread indexes obtained in the small tunnel furnace. A satisfactory correlation is indicated.

References

(1) Otto Brauns, "Ein Gerät zur Bestimmung des Flammwiderstandes von wandverkleidungs Platten," *Holz als Roh-und Werkstoff*, Berlin, p. 271 (1956).

(2) J. E. Ferris, "Fire Hazards of Combustible Wallboards," *Special Report No. 18.*, Commonwealth Experimental Building Station, Department of Works, Sydney, Australia (1954).

(3) Forest Products Laboratory, "Fire Test Methods Used in Research at Forest Products Laboratory," *Forest Products Laboratory Report No. 1443* (1953).

(4) D. Hird and C. F. Fischl, "Fire Hazard of Internal Linings," *National Building Studies Special Report No. 22*, Department of Science and Industrial Research, London, England (1954).

(5) A. F. Robertson, D. Gross, and J. Loftus, "A Method for Measuring Surface Flammability of Materials Using a Radiant Energy Source," National Bureau of Standards, Washington, D. C. (1956).

(6) Underwriters' Laboratories, "Fire Hazard Classification of Building Materials, *Bulletin of Research No. 32*, Underwriters' Laboratories (1944).

[10] Fire hazard, interpreted as hazard to life, comprises more than flame spread and includes intensity and duration of radiation, concentration of smoke, toxic gases, and choking fumes, temperature of the air at breathing level, and deficiency of oxygen.

(Continued from page 41)

individual atoms having a definite geometric arrangement with bonds of definite strength between them.

The manner in which each type of molecule will break down when it is bombarded by electrons and the quantity of each type of fragment depends on the strength of these atomic bonds, so that pattern of breakage and the number of fragments produced is an unmistakable "fingerprint" of each specific chemical compound. The characteristic is so unique and accurate for each compound as to constitute one of today's most widely used methods of analysis of complex mixtures.

When a sample in a vapor state is allowed to "leak" into an ionization chamber through a minute opening, its molecules are met by a stream of electrons from a white-hot filament. The molecules immediately take on electrostatic charges, and some are split into two or more charged pieces. Then both the charged molecules and their fragments are passed through a slit to form a beam, which is suddenly accelerated to high velocity.

The beam enters a curved analyzer tube, which is located in a strong magnetic field. Each of the swiftly moving particles making up the beam is deflected according to its molecular weight and its speed. The original beam therefore becomes a series of beams, each containing ions of one specific mass and traveling in one definite trajectory. It is necessary only to measure the intensity of each individual beam to obtain an analysis of the whole.

This is accomplished by means of a slit at the opposite end of the analyzer tube through which only ions having the correct combination of mass and velocity can pass. All other ions at each instrument setting will either fall short or overshoot the slit and thus be harmlessly grounded on the tube walls. Ions passing through the slit strike a collector, which converts their charge into electric current proportional to the abundance of the particles and hence to the concentration of the constituent. Each type of ion is successively focused on the slit by varying the accelerating voltage. Amplifiers increase the resulting signals so that they can be recorded. The permanent record obtained of the relative quantities is called the chemical compound's "mass spectrum."

Completeness of the analysis is a characteristic of mass spectrometer operation that is vital in the face of increasingly rigid product specifications. Every volatile material present in a substance or mixture in a concentration detectable by the instrument being used is registered on the mass spectrum. Such measuring and recording of substances even when they are unexpected makes the method of great value in both quantitative purity determinations and exploratory qualitative work.

The mass spectrometer is one of the new tools of science and industry which is drastically cutting the time-lag between the scientists' concepts and popular utilization. Every new discovery made with it opens new areas for further exploration.

Thus, both as an instrument for revealing new information on the world around us and as a tool for every day industrial production and control, the mass spectrometer is a major implement in our scientific age.

New Committee on Flexible Barrier Materials Expands Work in Specific Applications Field

FLEXIBLE Barrier Materials are being used in a variety of applications ranging from packaging to agricultural. The need for ASTM standards has led to the organization of a new technical committee in the Society which met for the first time on December 12 at the Sheraton-McAlpin Hotel in New York City. The committee has been given the designation F-2 on Flexible Barrier Materials and is the second committee in the family of technical committees concerned with specific applications.

Although three categories of materials come under the jurisdiction of the committee—basic materials, combined or composite materials, ,and barrier applications—it is recognized the primary emphasis will be in the fields of composite materials and barrier applications. Subcommittees will have jurisdiction over the development of standards in each of the three catagories. The function of the Subcommittee on Basic Materials will be mainly one of a liaison and coordination with other ASTM Committees which have jurisdiction over particular materials.

The scope approved at the organization meeting, as well as subsequently by the Board of Directors and at a recent meeting of the Steering Committee, is as follows:

> The development of definitions of terms and nomenclature, methods of test, and specifications for flexible barriers, including basic and composite materials and their application, and the promotion of research in this field. Standards covered by other committees shall be used when applicable.
>
> Typical flexible barrier materials are treated papers and fabrics, plastic films, and metallic foils, used alone or in various combinations.

Bylaws for the committee have been prepared by the Steering Subcommittee which is functioning until the bylaws are approved. Meetings of the Steering Committee are planned in the near future with the first full-fledged meeting of the committee scheduled for May 28, 1958 at the Hotel Statler in New York City at which time all subcommittees will meet to organize.

The elected officers are: chairman, Clifton Sutton, General Foods Corp.; vice chairman, L. F. Swec, Polymer Chemicals Div., W. R. Grace & Co.; and general secretary, T. M. Hill, Aluminum Company of America.

Penn State Offers Short Summer Course in Materials

Mechanical Properties of Materials—Their Determination, Interpretation and Significance.—This course, intended to keep design engineers and others engaged in research on materials abreast of new developments in the field, will be conducted from July 7 to 11, 1958.

Subjects to be covered include hardness of metals, plastic behavior of metals under simple and combined stresses, creep resistance and high-temperature properties of metals, fatigue strength of metals, effects of radiation on metals, recent developments in testing machines and instrumentation, and metals under high-speed loading. Lectures will be given by engineers and scientists in the field.

Federal Government Standards Index Changes

THE General Services Administration of the Federal Supply Service is charged with the responsibility for establishing specifications to be used by the Federal Government for procurement of materials and supplies. The GSA issues an annual Index of Initiation of Federal Specifications Projects, and monthly supplements.

The items listed below appeared in Supplement No. 12 for the month of February, 1958.

INITIATIONS

Title	Type of Action	Symbol or Number	FCS Code	FSSC Class	Assigned Agency & Preparing Activity
Soap, Grit (Hand, Paste, and Powder)	New	Fed. Std. No. 120	8520	51	GSA-FSS
Cable, Power, Electrical (Flexible Cord and Fixture Wire)	Am. 1	J-C-90a	6145	18	GSA-FSS
Cambric	Rev.	CCC-C-81a	8305	83	DOD-Army-QMC
Chambray	Rev.	CCC-C-231b	8305	83	DOD-Army-QMC
Glass, Cleaner, Powder	Am. 1	L-G-411	6850	51	GSA-FSS
Lacquer, Multicolored Dispersion Type (For Spray Application)	New New	TT-L-45a & TT-L-0045 (GSA-FSS)	8010	52	GSA-FSS
Liner Material, Grease-Proof (for Spirally Wound Fiber Containers)	New	PPP-L-00440 (GSA-FSS)	8135	..	GSA-FSS
Molding Plastic, Cellulose Acetate	Am. 1	L-M-505	9330	..	DOD-Navy-Ships
Molding Plastic, Polystyrene	Am. 1	L-M-520	9330	..	DOD-Navy-Ships
Molding Plastic, Polystyrene Modified	Am. 1	L-M-525	9330	..	DOD-Navy-Ships
Plastic Compounds, Molding Cellulose Acetate Butyrate; and Molded or Extruded Parts	Am. 2	L-P-349a	9330	..	DOD-Navy-Ships
Plastic Sheet, Modified Unplasticized Poly-(vinyl chloride) Rigid	Rev. New	L-P-510	9330	..	DOD-Navy-Ships
Soap, Grit (Hand, Paste, and Powder)	Am. 2	P-S-577	8 20	..	DOD-Army-Ord

PROMULGATIONS

Title	Type of Action	Symbol or Number
Boxes, Wood, Wirebound	AM 2	PPP-B-585
Copper Rods and Shapes; and Flat Products With Finished Edges (Flat Wire, Strips and Bars) (superseding FS QQ-C-502a)	Rev.	QQ-C-502b
Plastic Film, Flexible, Vinyl Chloride (superseding IFS L-P-00375 (GSA-FSS))	New	L-P-375a
Sacks, Shipping, Paper (superseding IFS PPP-S-0C48 (GSA-FSS) & FS UU-P-48b)	Rev.	UU-S-48c
Textile Test Methods	Am. 4 part-3	CCC-T-191b
Thread, Cotton (superseding IFS V-T-00276c(Army-GMC)	Rev.	V-T-276b

INTERIM FEDERAL SPECIFICATIONS ISSUED

Title	Type of Action	Symbol or Number
Insulation, Thermal, Mineral Wool, Block or Board and Pipe Insulation (Molded Type)	Am.	HH-I-562(GSA-FSS)
Lacquer, Multicolored Dispersion Type (for Spray Application)	New	TT-L-0C45(GSA-FSS)
Paint, Acrylic Emulsion, Exterior	New	TT-P-0019 Army-CE)
Paint, Poly(vinyl acetate) Emulsion, Exterior	New	TT-P-0055 (Army-CE)
Paint Styrene-Butadiene Emulsion, Exterior	New	TT-P-0099 (Army-CE)
Wire, Steel, Carbon, (Round, Bare and Coated)	Rev.	QQ-W-00461d(GSA-FSS)

CANCELLATIONS

Title	Symbol or Number	Reason for Cancellation
Burlap; Jute	O-C-746	Superseded by Fed. Spec. O-I-490
Corrosion Inhibitor Compound (for Ethylene Glycol Antifreeze and/or Water)	CCC-B-811	Superseded by Fed. Spec. CCC-C-467

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PERSONALS...

News items concerning the activities of our members will be welcomed for inclusion in this column.

Several ASTM members were honored at the Annual Meeting of the American Welding Society in St. Louis in April. **R. David Thomas, Jr.,** president of Arcos Corp., Philadelphia, Pa., was elected a vice-president of AWS, also was presented with the Samuel Wylie Miller Memorial Medal for "meritorious achievement which has contributed conspicuously to the advancement of the art of welding and cutting." **Leon C. Bibber,** chief research engineer, welding, Applied Research Lab., United States Steel Corp., Monroeville, Pa., was made an Honorary Member of the American Welding Society, in recognition of his exceptional accomplishments in the development of the welding art. **Lynn S. Beedle,** research associated professor and chairman, Structural Metals Div., Fritz Laboratory, Lehigh University, Bethlehem, Pa., with George C. Driscoll, Jr., research instructor, Department of Civil Engineering at Lehigh, received the A. F. Davis Silver Medal for their paper "The Plastic Behavior of Structural Members and Frames" (published in the June, 1957 issue of *The Welding Journal*). **A. J. Moses,** vice-president, Hedges-Walsh-Weidner Div., Combustion Engineering, Inc., Chattanooga, Tenn., received a Meritorious Certificate Award, in recognition of efforts and contributions to the advancement of welding. **Edward C. Miller,** inspection engineer, Oak Ridge National Laboratory, Union Carbide Nuclear Co., Oak Ridge, Tenn., was elected an AWS Director-at-Large.

A number of ASTM members were among thirty SAE technical committee members who recently received Certificates of Appreciation from the Society of Automotive Engineers for outstanding contributions toward furthering the development of technical information and specifications used by aeronautical and automotive industries. These included **Carlton E. Carrigan,** metallurgist, Fairchild Engine Div., Fairchild Engine and Airplane Corp., Deer Park, N. Y.; **Henry D. Monsch,** metallurgist, Aluminum Co. of America, Pittsburgh, Pa.; **Paul P. Mozley,** metallurgist, Lockheed Aircraft Corp., Burbank, Calif.; **R. W. Rousch,** chief materials engineer, Timken-Detroit Axle Div., Rockwell Spring and Axle Co., Detroit, Mich.; and **F. P. Zimmerli,** director of engineering and research, Associated Spring Corp., Bristol, Conn.

Peter Briggs, of Middletown, N. Y., who will graduate in mechanical engineering from Rensselaer Polytechnic Institute in June, is one of five young engineers selected by Tau Beta Pi, national engineering honor society, for graduate fellowship awards in 1958–1959. He will take advanced work in mechanical engineering either at Rensselaer or at Massachusetts Institute of Technology. Mr. Briggs was recipient of an ASTM Student Membership Prize Award for 1957–1958.

H. T. Cover has retired as assistant vice-president of operation and chief of motive power, Pennsylvania Railroad Co., Philadelphia, Pa.

Rose J. Gilmore, president, Superior Steel & Malleable Castings Co., Benton Harbor, Mich., took office as president of Steel Founders' Society of America at the Fifty-Sixth Annual Meeting of the Society in Chicago in March.

Allen G. Gray, formerly technical editor, **Steel,** Penton Publishing Co., is now editor, **Metal Progress,** American Society for Metals.

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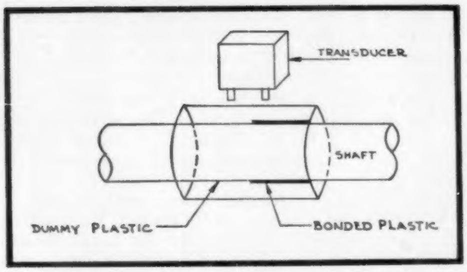

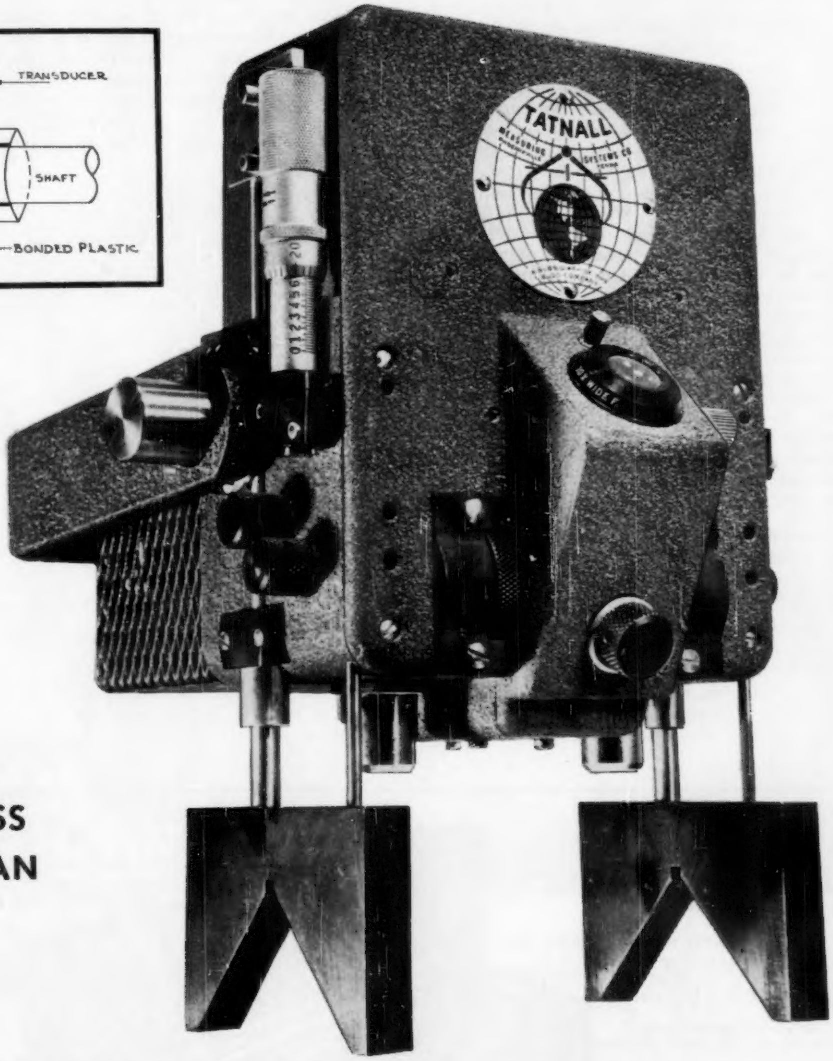

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FOR FURTHER INFORMATION CIRCLE 906 ON READER SERVICE CARD

(*Continued from page 74*)

Eugene Willis Greenfield, for several years with Kaiser Aluminum and Chemical Corp., Spokane, Wash., as research supervisor for the department of metallurgical research, and previously for many years research engineer and supervisor, electrical engineering laboratory, Anaconda Wire & Cable Co., New York City, has been named director of the Division of Industrial Research, Washington State College Institute of Industrial Research, Pullman. He fills the vacancy left when the former division director, Raymond L. Albrook, died in May of 1957. Dr. Greenfield will head a large staff of engineers, research scientists, and technicians in carrying on research activities dealing with almost every facet of industrial production in the Pacific Northwest. Dr. Greenfield has been serving on ASTM Committees D-9 on Electrical Insulating Materials, D-11 on Rubber and Rubber-Like Material, and D-20 on Plastics.

Vasudeo N. Gunaji, formerly engaged as a consulting civil engineer, now is professor of civil engineering, College of Engineering, Poona, India.

Maurice F. Hasler, president and director of research for Applied Research Laboratories, Glendale, Calif., was presented with the fourth annual Beckman Award for outstanding contribution to the field of chemical instrumentation at the 133rd national meeting of the American Chemical Society in San Francisco in April. He was selected for the Award as a result of his development of a direct-reading optical emission spectrometer which gives a complete chemical analysis of a metal in one minute. Dr. Hasler is active in ASTM Committee E-2 on Emission Spectroscopy.

Harry J. Huester, Commander, USNR, recently at the U. S. Naval Base, Philadelphia, Pa., and formerly at the Jacksonville Naval Station, also for many years with the Aeronautical Standards Group in Washington, D. C., has opened consulting and technical services offices at 4621—36th St., Arlington, Va. Cmdr. Huster is a long-time active member of the Society.

Charles R. Ince has been elected to the board of trustees of St. Joseph Lead Co., New York City. He has been associated with the company since 1929 and a vice-president since 1951.

Herbert S. Kalish, formerly with Sylvania-Corning Nuclear Corp., Bayside, N. Y., has accepted a position as chief, materials section, Nuclear Fuel Research Dept., Metallurgical Labs., Olin-Mathieson Chemical Corp., New Haven, Conn.

E. J. Kilcawley, professor and head, Division of Soil Mechanics and Sanitary Engineering, Renssalear Polytechnic Institute, Troy, N. Y., has announced the establishment of a new curriculum for Rensselaer on Environmental Engineering. The new curriculum places more emphasis than conventional programs in this field on mathematics and fundamental sciences, with a wide range of electives. Professor Kilcawley has been active for many years in ASTM, serving as chairman of Committee D-18 on Soils for Engineering Purposes since 1944.

Lester Koenitzer, until recently materials engineer, Concrete Paving Evaluation Section, U. S. Army Engineer District, U. S. Corps of Engineers, Sacramento, Calif., has been transferred to Dezful, Iran, as materials engineer for the U. S. Army Engineer District, Gulf.

Ray E. Moser, formerly with Adolf Frese Corp., Los Angeles, Calif., is now sales manager, A. Daigger & Co. of California, Los Angeles.

H. D. Newell has retired as chief metallurgist and metallurgical consultant, The Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa. Mr. Newell has represented his company for the past 29 years on Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys. He had served as secretary of the Committee from 1930 to 1950. Mr. Newell resides in Beaver Falls, Pa. (Mt. Rt. 15, Clayton Rd.).

(*Continued on page 79*)

(Continued from page 76)

Theodore P. Pajak, formerly regional manager, Hexcel Products, Inc., Havre de Grace, Md., is now eastern regional manager, Narmco, Inc., Bel Air, Md.

F. W. Reinhart, head of the plastics section, National Bureau of Standards, was awarded an honorary Doctor of Science degree, April 17, by Juniata College, Huntingdon, Pa., for outstanding contributions to research and standards in plastics and adhesives. Mr. Reinhart is chairman of Committee D-20 on Plastics.

Thomas E. Ronay, previously director of research, Nukem Products Corp., Buffalo, N. Y., has accepted a position as supervisor, Laminated Products Sec., The Richardson Co., Melrose Park, Ill.

Bruno Sachs has been elected to the board of directors of Tenney Engineering, Inc., Union, N. J. Dr. Sachs is vice-president in charge of engineering and manufacturing for Tenney, one of the largest producers of environmental test equipment.

Emil Schmid, until recently executive vice-president, has been appointed president of Sika Chemical Corp., Passaic, N. J. He has been with Sika since 1934.

Robert H. Shenk, formerly chief engineer, Wiedemann Machine Co., Philadelphia, Pa., is now vice-president, Zurn Industries, Inc., Erie, Pa.

John R. Smyth, chief control engineer, Exide Industrial Div., Electric Storage Battery Co., Philadelphia, Pa., has been named assistant director of engineering. Mr. Smyth serves on ASTM Committee D-11 on Rubber and Rubber-Like Materials and its subcommittee concerned with hard rubber.

Adam M. Steever has resigned his position with Columbia Tool Steel Co., Chicago Heights, Ill., to retire to Florida.

Fred H. Stross, research supervisor in Shell Development Co.'s Emeryville (Calif.) Research Center, has accepted chairmanship of a newly formed group in the National Research Council. He will head a subcommittee of the Analytical Chemistry Committee of the Council's Division of Chemistry and Chemical Technology. The new group is known officially as the "Subcommittee of Definitions and Units and Modes of Publication in Gas Chromatography." Serving under Dr. Stross on the new subcommittee are Drs. **Ralph O. Clark** of Gulf Oil Co., Pittsburgh, Pa., and **George Matsuyama** of Union Oil Co., Brea, Calif. Dr. Stross and Messrs. Clark and Matsuyama all are very active in a number of the research divisions of ASTM Committee D-2 on Petroleum Products and Lubricants.

Rolla H. Taylor has been appointed assistant sales manager of Scott Testers Inc., Providence, R. I. Mr. Taylor has participated in the work of a number of ASTM technical committees for many years.

J. Lawrence Thompson has retired from the U. S. Naval Engineering Experiment Station, Annapolis, Md. Mr. Thompson had represented the Experiment Station for many years on Committee A-5 on Corrosion of Iron and Steel.

L. A. Wagner has retired as vice-president of the Missouri Portland Cement Co., St. Louis. Mr. Wagner represented the company's Sustaining membership for many years, also served on several of the technical committees.

Arthur J. Warner, formerly with Federal Telecommunication Labs., Div. of International Telephone & Telegraph Corp., Nutley, N. J., has joined DeBell & Richardson, Inc., consulting engineers in the plastics field at Hazardville, Conn., as an insulating and semiconductor consultant to the electrical and electronics industries. Mr. Warner has been active for many years in the work of ASTM Committee D-20 on Plastics. He is a former secretary of this main group.

C. H. Welch, president, The Alloy Cast Steel Co., Marion, Ohio, has been elected a director of the Steel Founders' Society of America.

E. G. West, technical director, Aluminum Development Assn., London, England, has been making an extensive tour of Canada and the United States, visiting the principal aluminum producers and fabricators, his itinerary covering Oakland, Louisville, Pittsburgh, Chicago, Richmond, Washington, New York, Toronto, Montreal, and Kingston (Ontario). Dr. West has been the technical director of ADA since its formation in 1945.

Edward Wichers, veteran of 40 years' service with the National Bureau of Standards, Washington, D. C., has been named associate director for chemistry in the Bureau. Dr. Wichers succeeds Dr. **Wallace R. Brode,** recently granted a leave of absence to become science adviser to the Secretary of State.

ASTM honorary member and former director, **Louis H. Winkler,** metallurgical engineer with Bethlehem Steel Co., Bethlehem, Pa., was "saluted" by *The Iron Age* in its March 27, 1958, issue. The timely article noted that what the aircraft and missile metallurgists are going through now, Mr. Winkler has experienced many times in the past 39 years in developing railroad steel, wire, pipe, and other steel products. Commenting on the limit of accomplishment of any branch of science by itself, Mr. Winkler emphasized the need for cooperation between the various branches of science and engineering. For many years Mr. Winkler has contributed to the activities of ASTM Committee A-1 on Steel; currently he serves as vice-chairman of the subcommittee concerned with steel rails and accessories.

(Continued on page 98)

NEW MEMBERS.......

The following 158 members were elected from March 10 to April 16, 1958, making the total membership 9341 .... Welcome to ASTM

Note—Names are arranged alphabetically—Company members first then individuals—Your ASTM Year Book shows the areas covered by the respective Districts

CHICAGO DISTRICT

Dielectric Materials Co., R. C. Bartlett, engineer, 5315 N. Ravenswood Ave., Chicago 40, Ill.

Baden, Thomas A., engineering dept., Donaldson Co., Inc., 666 Pelham Blvd., St. Paul 14, Minn. [A]*

Bowen, Quentin C., chief analytical chemist, Sundstrand Aviation Div. of Sundstrand Machine Tool Co., 2421 Eleventh St., Rockford, Ill. For mail: Birch Ave., R. R. 1, Rockford, Ill. [A]

Clark, James G., partner, Clark, Daily & Dietz, Consulting Engineers, 211 N. Race, Urbana, Ill.

Cosgrove, Michael F., engineer, Commonwealth Edison Co., Technical Center, 1319 S. First Ave., Maywood, Ill.

Decker, Richard H., building commissioner, 54 South Brockway, Village Hall, Palatine, Ill.

Gottschalk, Gordon W., technical director, Thiem Products, Inc., 9800 W. Rogers St., Milwaukee 19, Wis.

Haverkos James R., assistant sales manager, Soiltest, Inc., 4711 W. North Ave., Chicago 39, Ill.

Hock, Walter L., chemical engineer, National Dairy Products Corp., 923 Waukegan Rd., Glenview, Ill.

Masterson, Frederick A., president, American Crossarm and Conduit Co., 7726 Sheridan Rd., Chicago 26, Ill.

Musser, Charles W., chief engineer, Koontz-Wagner Electric Co., Inc., 343 Lincolnway West, South Bend 1, Ind.

Oetzel, J. George, vice-president, engineering research, Warner Electric Brake and Clutch Co., Beloit, Wis.

Swanson, R. H., chief engineer, Manitowoc Equipment Works, 621 Quay St., Manitowoc, Wis.

Tongren, J. C., Watervliet Paper Co., Watervliet, Mich.

Whitby, Kenneth T., assistant professor, Mechanical Engineering Dept., University of Minnesota, Minneapolis 14, Minn.

CLEVELAND DISTRICT

Doane, Philip E., partner, Sauter, Ritchie & Doane, 1830 Portage Trail, Cuyahoga Falls, Ohio.

James, Elmer, quality control engineering, testing and specifications, American Greetings Corp., 1300 W. Seventy-eighth St., Cleveland 2, Ohio.

DETROIT DISTRICT

Ibbs, John W., assistant superintendent of power production, Mistersky Power Station, Public Lighting Commission, 5425 W. Jefferson, Detroit 9, Mich.

Tippman, Melvin, chemist, Checker Motors Corp., Kalamazoo, Mich. For mail: 1811 Cambridge Dr., Kalamazoo, Mich.

Weinheimer, C. M., staff engineer, engineering lab. and research dept., The Detroit Edison Co., 2000 Second Ave., Detroit 26, Mich.

NEW ENGLAND DISTRICT

Aldon Spinning Mills Corp., The, Alfred W. Cavedon, treasurer, Talcottville, Conn.

Crop Protection Inst., Inc., Robert J. Norton, director, Durham, N. H.

Davidian, Arthur, director of lab., Wamsutta Mills, Wamsutta St., New Bedford, Mass.

Fellows, Douglas M., administrative director, The Ward School of Electronics, University of Hartford, 44 Niles St., Hartford 5, Conn.

Flowers, Leonard C., materials and process engineer, Westinghouse Electric Corp., 653 Page Blvd., Springfield 2, Mass.

Katz, Maurice H., vice-president, Atlantic Aluminum and Metal Distributors, Inc., Box 640, East Springfield, Mass.

Oliver, Robert B., manager, New England Materials Laboratory, Box 128, Medford, Mass.

Stanley, John R., Jr., metallurgical technician, Leach & Garner Co., Pearl St., Attleboro, Mass. [A]

Stritter, Edward E., chief chemist, Chase and Sons, Inc., 26 Spruce St., North Quincy, Mass.

Yorgiadis, Alexander, product manager and chief engineer, Dynamics Dept., Baldwin-Lima-Hamilton Corp., Electronics and Instrumentation Div., Waltham 54, Mass.

NEW YORK DISTRICT

American Machine and Foundry Co., J. H. Bergen, standards administrator, 200 Henry St., Stamford, Conn. [S]†

Trubek Laboratories, Inc., The, Leonard Wirston, chemist, State Highway No. 17, East Rutherford, N. J.

Baker, William Waverly, assistant materials test engineer, Sperry Gyroscope Co., Materials Lab., 104–14 177th St., Jamaica 33, L. I., N. Y.

Balestier, Elliot, Jr., assistant to president, and manager, division of special service, Visking Co., Division of Union Carbide Corp., 6733 W. Sixty-fifth St., Chicago 38, Ill. For mail: 210 Main St., Hackensack, N. J.

Bissell, T. A., executive secretary, Society of Plastic Engineers, Inc., 34 E. Putnam Ave., Greenwich, Conn.

Bogot, Alexander, assistant chief engineer, Combustion Engineering, Inc., 200 Madison Ave., New York 16, N. Y.

Bogumil, Robert W., member of technical staff, Bell Telephone Laboratories, Mountain Ave., Murray Hill, N. J. For mail: 146 Canoe Brooks Parkway, Summit, N. J.

Bower, William M., chief process engineer, Photocircuits Corp., 31 Sea Cliff Ave., Glen Cove, N. Y. [A]

Cavanaugh, John C., technical officer, Imperial Chemical Industries (New York), Ltd., 488 Madison Ave., New York 22, N. Y.

Cohen, Bertram, chemist, C. B. Dolge and Co., Indian Hill Rd., Westport, Conn.

Dominiquez, George, products dept., Geigy Dyestuff Div., Geigy Chemical Corp., Ardsley, N. Y. For mail: 3605 Kingsbridge Ave., Bronx 63, N. Y [A]

Guterman, Jack, partner and general manager, American Valve Manufacturing Co., Coxsackie, N. Y.

Kimble, Richard E., president, Kimtex Service Laboratories, 13 Florida Ave., Paterson, N. J.

Lieber, Sidney, president, Unit Process Assemblies, Inc., 61 E. Fourth St., New York 3, N. Y.

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(*Continued from page 80*)

Matsunaga, Hideo, assistant manager, engineering dept., Maruzen Oil Company of U.S.A., Inc., 60 E. Fifty-sixth St., New York, N. Y.
Munisteri, N. C., assistant to vice-president, sales, Weksler Instruments Corp., Freeport, L. I., N. Y. For mail: 63 Laurel Dr., Massapequa Park, L. I., N. Y.
Palm, A. E., chief engineer, International Smelting and Refining Co., Raritan Copper Works, Perth Amboy, N. J.
Patience, Daniel A., works metallurgist, Worthington Corp., 401 Worthington Ave., Harrison, N. J.
Schlegel, Walter A., chief metallurgist, Carpenter Steel of New England, Inc., 837 Seaview Ave., Bridgeport 7, Conn.
Smith, Charles T., manager, Danbury Metal Finishing Co., 4 Thorpe St., Danbury, Conn.
Spitz, David, sales manager, Century Cement Co., 18 E. Sunrise Highway, Freeport, N. Y.
Steele, Arthur B., manager, technical service, Union Carbide Chemicals Co., 30 E. Forty-second St., New York 17, N. Y.
Sutton, C. R., coördinator, nuclear energy, The International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.
Wagner, Melvin, manager, packaging materials div., Acme Backing Corp., Canal and Ludlow Sts., Stamford, Conn.

NORTHERN CALIFORNIA DISTRICT

Overseas Merchandise Inspection Co., Ltd., S. Motose, chief inspector, 25 California St., San Francisco, Calif.
Allen, William Stephen, partner, Anshen & Allen, Architects, 461 Bush St., San Francisco 8, Calif.
Bloch, Manfred G., research engineer, The Dow Chemical Co., Box 351, Pittsburgh, Calif.
Creegan, Patrick J., principal, Creegan & D'Angelo, Civil Engineers, Box 248, Saratoga, Calif.
Eukel, Warren W., chief of operations and electronics, Applied Radiation Corp., 2404 N. Main St., Walnut Creek, Calif.
Russe, Charles F., district manager, Pittsburgh Testing Laboratory, 651 Howard St., San Francisco 5, Calif.
Sabouni, Bahidj B., director of research, Soule Steel Co., 1750 Army St., San Francisco 19, Calif.

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Hall, Maynard E., associate professor of engineering, West Virginia Institute of Technology, Engineering Bldg., Montgomery, W. Va.
Koenig, Rodney J., assistant engineer, Ohio State Highway Testing Lab., 155 W. Woodruff Ave., Columbus, Ohio. For mail: 1232 Delno Ave., Columbus 24, Ohio.
Radar, Don S., chief chemist, The Ohio Silica Co., Richmondale, Ohio. For mail: 68 W. Second St., Chillicothe, Ohio
Vogt, Robert Schwartz, junior partner, Vogt, Ivers, Seaman and Associates, 34 W. Sixth St., Cincinnati 2, Ohio. [A]

PHILADELPHIA DISTRICT

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Celikiz, Gultekin, research chemist, Philadelphia Textile Inst., Schoolhouse Lane and Henry Ave., Philadelphia 44, Pa. For mail: 5838 N. Twelfth St., Philadelphia 41, Pa. [A]
Oberholtzer, L. C., plastics engineer, Philco Corp., Appliance Div., C and Tioga Sts., Philadelphia 34, Pa
Shoemaker, E. L., vice-president, Warner Co., 1721 Arch St., Philadelphia 3, Pa.
Stellabotte, M. L., research engineer, Naval Air Material Center, Philadelphia Naval Base, Philadelphia 12, Pa. For mail: 384 Westfield Dr., Broomall, Pa.
Tudor, Carl F., president, Jaegle Paint and Varnish Co., 1607 S. Twentieth St., Philadelphia 45, Pa.
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Brunot, John B., Jr., hot mill superintendent, Pittsburgh Tube Co., 1817 Pennsylvania Ave., Monaca, Pa.
Church, Herbert C., director, Process and Product Development, New York and Pennsylvania Co., Inc., Lock Haven, Pa.
Lucas, Christian G., manager, Quality Control Dept., Sharon Steel Corp., Sharon, Pa.
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Littmann, Ellis C., president, Nixdorff-Krein Manufacturing Co., 916 Howard St., St. Louis, Mo.

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SOUTHEAST DISTRICT

General Shale Products Corp., Robert B. Hockaday, manager of research, Kingsport, Tenn.
Brooks, Everett B., president, Ebcap Supply Co., Box 1258, Atlanta 1, Ga.
Cook, John, chemist, Sec Manufacturing Co., 61 N. E. Twenty-sixth St., Miami 37, Fla.
Dedwylder, Rozier, partner, Pound, Flowers & Dedwylder, Architects, 416 Twelfth St., Columbus, Ga.
Dobbins, Porter K., civil engineer, Childersburg Development Corp., Box 206, Childersburg, Ala. [A]
Ewerling, J. Lee, assistant manager, Southern Builders Supply Co., 314 Forty-second Ave., N., Nashville 9, Tenn.
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Gray, J. Ashton, Concrete Dept., Duracrete, Leesburg, Fla., For mail: Box 781, Leesburg, Fla.
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Parker, Harry S., Engineering Ceramics Section, National Bureau of Standards, Connecticut Ave. and Van Ness, Washington 25, D. C.
Redwine, Doris J., Mrs., testing supervisor, Collins & Aikman Corp., Albemarle, N. C.
Tosner, William F., physicist consultant, Building Technical Div., National Bureau of Standards, Washington 25, D. C.

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Aykroyd, G. C., chief engineer, Disher Steel, Division of Dominion Structural Steel, Ltd., Disco Rd., Rexdale P. O., Ont., Canada.
Crampton, W. F., acting director of purchasing and stores div., City of Toronto, Rm. 18, City Hall, Toronto, Ont., Canada.
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Houghton, Russell M., research manager, Conap Co., 619 S. Union St., Olean, N. Y.
Lavery, R. G., production engineer, Production and Design Dept., Precast Haydite, Ltd., 26 Hollinger Rd., Toronto 16, Ont., Canada. [A]
MacInnis, Cameron, research engineer, Hydro-Electric Power Commission of Ontario, 620 University Ave., Toronto 2, Ont., Canada.
McAllister, Thornton W., inspector, General Construction, 206 Metoxet St., Ridgeway, Pa.
Metil, Ignatius, chief chemist, Nukem Products Corp., 111 Colgate Ave., Buffalo 20, N. Y.
Wade, G. S., technical manager, Nashua (Canada), Ltd., Box 299, Peterborough, Ont., Canada.

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(*Continued on page 86*)

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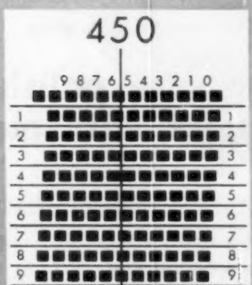

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(*Continued from page 84*)

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Montgomery, Howard E., section supervisor, Sandia Corp., Sandia Base, Albuquerque, N. Mex., For mail: 614 Ridge Pl., N. E., Albuquerque, N. Mex.

Smith, Charles Roland, consulting engineer, Arizona Public Service Co., Box 2591, Phoenix, Ariz. For mail: 17 W. Colter St., Phoenix, Ariz.

OTHER THAN U. S. POSSESSIONS

British Columbia Power Commission, R. C. McMordie, chief engineer, Box 500, Victoria, B. C., Canada.

Canadian General Electric Co., Ltd., Robert H. Greene, material and process engineer, 5781 Notre Dame St., E., Montreal 5, P. Q., Canada.

Dunlop South Africa Ltd., G. J. Greenfield, technical manager, Box 925, Durban, South Africa.

General Motors Argentina, S. A., Raul Capuano, chief product engineer, Rio Limay 1725, Buenos Aires, Argentina.

Holmes Foundry, Ltd., C. J. Koehler, general manager, Insulation Div., 200 Exmouth St., Sarnia, Ont., Canada.

Villiers Australia Pty., Ltd., W. B. Steen, joint managing director, Box 237, Ballaarat, Victoria, Australia.

Western Alloys and Metals, Ltd., R. S. Cox, managing director, 22 E. Second Ave., Vancouver 10, B. C., Canada.

Anderson, James S., chief metallurgist, General Motors-Holden's Ltd., Box 1714, Fishermen's Bend, Melbourne, Victoria, Australia.

Bentley, R., general manager, Solus-Schall, Ltd., 15/18 Clipstone St., London, W. 1, England.

Cartagena, Universidad de, Facultad de Ingenieria, Cartagena, Columbia.

Chehade, Salvador, assistant superintendent, S. A. Yarur, Casilla 129-D, Santiago, Chile.

Cisotti, F., manager, Laboratori Ing. Pavone, 54 Via Zuretti, Milan, Italy.

Dopereiro, Francisco Trincado, chemical science doctor, Rey Francisco 4, Madrid, Spain.

Fabris, Temistocle, manager, Societa A.C.N.A., Cesano Maderno, Milan, Italy.

Gaudreau, Marcel, chief engineer, Terry Machinery Co., Ltd., 6045 Cote de Liesse, St. Laurent, P. Q., Canada.

Goll, Gerardo Vincke, Lopez Puigcerver, 34, Palamos, Gerona, Spain.

Granger, Vincent Louis, chairman and managing director, Rhodesian Testing Laboratories (Pvt.), Ltd., Box 2259, Salisbury, Southern Rhodesia.

Greday, Tony, research metallurgical engineer, Centre National de Recherches Metallurgiques, Abbaye du Val-Benoit, Liege, Belgium. For mail: 21, rue Maghin, Liege, Belgium.

Iwanson, Walter F., civil engineer, Department of Transport, Federal Bldg., Edmonton, Alta., Canada. For mail: 10963 Seventy-second Ave., Edmonton, Alta., Canada.

L'Hermite, Robert, director of laboratories, Centre Experimental de Recherches et D'Etudes du Batiment et des Travaux Publics, 12 rue Brancion, Paris XV, France.

Madore, G. W., manager of engineering, Foresteel Products, Ltd., 2405 Ville Marie St., Montreal, P. Q., Canada.

Moguel Galindo, Jose Joaquin, textile engineer, Celanese Mexicana, S. A., Plasa Santos Degollado, No. 10-7°, Piso, D. F. 1, Mexico. For mail: Guerrero 49, San Jeronimo 20, D. F., Mexico. [A]

Mortensen, James E., asphalt engineer, Esso Standard Oil, S. A., Apartado 4087, Havana, Cuba.

Palmer, Stephen Edmund, Edmonton branch manager, The Warnock Hersey Co., Ltd., 128 Elmslee St., Montreal 32, P. Q., Canada. For mail: 10231 Seventy-first St., Edmonton, Alta., Canada.

Pascoe, Reginald A., chief engineer, Frigidaire Div., General Motors-Holden's Ltd., Box 163, Princes Highway, Dandenong, Victoria, Australia.

Porter, Stuart Stanley, technical assistant, Marston Sons and Co., Anstey, Leicestershire, England. For mail: 28 Leicester Rd., Groby, Leicestershire, England.

Rommelt, Heinrich, Konrad-Witz-Strasse 9, Mannheim-Neuostheim, Germany.

Suez Canal Authority (Zurich Office), Ahmad Zaki, director, Seefeldstrasse, 45, Zurich 8, Switzerland.

Wang, H. C., president, China Superintendence Co., Ltd., 67, First Section, Chungking South Rd., Taipei, Taiwan, China. For mail: 10, Lane 311, Antung St., Taipei, Taiwan, China.

White, Leonard Faulkner, general manager, Metal Manufactures, Ltd., Port Kembla, New South Wales, Australia.

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* [A] denotes Associate Member.
† [S] denotes Sustaining Member.

DEATHS...

William Waite Broughton, plant manager, Stella Products Corp., Livingston, N. J.; formerly with Newton-New Haven Co., also New Jersey Zinc Co. (Feb. 17, 1958). Personal member since 1955, also previously from 1948 to 1954. Served through the years on Committee B-6 on Die-Cast Metals and Alloys and several subcommittees.

Warren G. Brown, director of research, Western Waterproofing Co., Detroit, Mich. Member since 1943.

Horatio Seymour Mattimore, engineering consultant, Colonial Park, Pa.; for many years (1919–1943) engineer of materials for the Pennsylvania Department of Highways, and previously associated with the New York State Highway Department. More recently he had served as consultant on floating concrete drydock construction for the U. S. Navy, and to design and construction engineers for the New Jersey Turnpike and New Jersey Garden State Highway. He also had been staff consultant with Miller-Warden Associates, Swathmore, Pa. A loyal member of ASTM since 1914, Mr. Mattimore, has been active in a number of the technical committees, particularly C-1 on Cement, C-9 on Concrete and Concrete Aggregates, and D-4 on Road and Paving Materials. (Each of these main groups had elected him an honorary member, in recognition of valued contributions.) He served a term as chairman of Committeee D-4. Mr. Mattimore also served on the ASTM Board of Directors, 1928–1930. He was honored by the Society in 1952 by an ASTM Award of Merit for distinguished service. Mr. Mattimore's other affiliations included the Highway Research Board, American Association of State Highway Officials (past-chairman, Committee on Materials), Association of Highway Officials of the North Atlantic States, American Society of Civil Engineers, and National Society of Professional Engineers (past-president, Harrisburg Chapter).

Frank R. Olmstead, chief, Soils and Foundations Branch, Division of Physical Research, Bureau of Public Roads, Washington, D. C., died in his office at Gravelly Point on April 2, 1958. Only 53 years of age and at the high point of a career as a leading soils engineer, his passing will be deeply felt in his profession and by his friends. Mr. Olmstead had been associated with the Bureau since 1943. One of his outstanding technical accomplishments was the development of a cooperative arrangement between the Bureau and the Soil Conservation Service of the Department of Agriculture, through which a great quantity of existing knowledge of the agricultural properties of the soils of the United States was made available for the use of highway engineers. He also

(Continued on page 98)

NEWS NOTES ON

Laboratory Supplies and Testing Equipment

Note—This information is based on literature and statements from apparatus manufacturers and laboratory supply houses. The Society is not responsible for statements advanced in this publication.

CATALOGS & LITERATURE

Quantovac—Pamphlet describes the first large vacuum spectrometer which extends the spectrum range into the far ultraviolet.
Applied Research Labs. 2379

Infrared Instruments—Low-cost infrared spectrophotometers for routine laboratory qualitative and quantitative analyses are described and illustrated in a new infrared brochure, *Bulletin 724.*
Beckman/Scientific Instruments Div. 2380

Gas Analyzer—A four-page bulletin, *Bulletin TC-4012,* provides detailed information on the applications, features, principle of operation, and specifications of the Beckman Thermal Conductivity Gas Analyzer, Model 7C.
Beckman/Process Instruments Div. 2381

Absorption Cell—Absorption cells and other sample handling accessories for the Beckman B, DU, DK-1, and DK-2 spectrophotometers are described and illustrated in a new cell catalog, *Bulletin 729.*
Beckman/Scientific Instruments Div. 2382

High Pressure Compression Systems—Brochure describes new models of pre-engineered central compression systems for supplying air or gases at 3500 to 12,000 psi for testing uses.
High Pressure Pneumatics Div., Cardox Corporation 2383

Spectrophotometers—A new bulletin, *Bulletin B-240-A,* describes spectrophotometer, now offered in 3 models and with a choice of 4-power supply arrangements.
Coleman Instruments, Inc. 2384

Photofluorometer—*Bulletin B-245* gives an up-to-date description of the electronic photofluorometer, Model 12C, which is used for the accurate measurement of metal complexes and other compounds measurable by fluorescence.
Coleman Instruments, Inc. 2385

Force Gauge—A new illustrated six-page folder, *Bulletin 11E,* describing its complete line of mechanical force gages has been issued.
W. C. Dillon & Co., Inc. 2386

Separatory Funnel—Separatory funnel flyer gives prices of three funnel types, all featuring leakproof, freezeproof Lab-Crest stopcocks that use no grease.
Fischer & Porter Co. 2387

Colorimeter—*Bulletin FS-273,* an eight-page folder, describes new colorimeters designed for use for ASTM Method D 1500.
Fisher Scientific Co. 2388

VHF-UHF Equipment.—Twelve-page catalog describes a complete and integrated line of high-frequency measuring equipment.
General Radio Co. 2389

Optical Instrument—Scan-A-Scales—used on any production or inspection equipment requiring accurate, reproducible linear settings—are the subject of a six-page folder.
F. T. Griswold Mfg. Co. 2390

Laboratory Spotlight—A 16-page booklet lists laboratory supplies.
Harshaw Chemical Co. 2391

Highway Test Apparatus—A new 5-page catalog, *Catalog #10,* of apparatus for testing soils, cement, concrete, asphalt, aggregates and general laboratory apparatus, including balances, ovens, and general laboratory items is announced.
C. A. Hogentogler & Co. 2392

Friction Tester—The new A-6 friction and wear tester is described and illustrated in a bulletin. The tester is an instrument used for the simulation of most types or combinations of wear, heat and atmospheric conditions that are encountered by solid lubricants.
Hohman Plating & Mfg. Co. 2393

Clamps—*Folder No. 2* describes clamps for use with strain gages.
Hunter Spring Co. 2394

Particle Size—M-S-A particle size analyzer is the title of *Bulletin No. 0708-1* recently issued. The 4-page bulletin presents a new low-cost, general purpose instrument for 0.1 to 40-micron particles.
Mine Safety Appliances Co. 2395

Indicating Thermometers—*Catalog C60-2* describes the complete line of rectangular case, filled system thermometers. These indicators, recorders, transmitters, and electric or pneumatic control instruments are covered in detail in the new 56-page catalog.
Minneapolis-Honeywell Regulator Co. 2396

(*Continued on page 93*)

(*Continued from page 90*)

Hardness Tester—Three catalogs describing hardness testers now being offered are: Frank Optical Hardness Tester "Finotest"; Frank Universal Hardness Tester No. 505; and Frank Full Universal Hardness Tester "Frankoskop."
Opto-Metric Tools, Inc. 2397

X-Ray Analysis Theory—A new 12-page booklet titled "X-ray Analysis Theory & Instrumentation" is available.
Philips Electronics, Inc. 2398

Centrifuge—A new two-page bulletin on the recently announced low price, increased capacity, infinite speed selection table model centrifuge is available.
Precision Scientific Co. 2399

Humidty Control Unit—Two-color bulletin, *Bulletin No. 61*, illustrates and describes the compact self-contained control unit, including apparatus for heating, cooling, dehumidifying, and circulating air into the laboratory. Dry bulb temperatures may be maintained within ½ F and relative humidity within 1 per cent.
J. O. Ross Engineering 2400

Core Analysis—Engineering data sheet *E-57-3* titled "Maintaining Constant Pressures in Core Analysis," covers the application of Constametric miniPumps in core analysis.
Milton Roy Co. 2401

Megohmmeter—*Bulletin No. 1*, describes Type 8 Electrometer-Meghommeter. Four-page folder includes text, photographs, schematic diagrams, complete technical specifications, and price of instrument.
Walter N. Trump 2402

LABORATORY ITEMS

Plastic Vacuum Desiccator—Combines the transparency of glass with the impact and shatter resistance of plastic to provide the optimum in utility and safety.
Ace Glass, Inc. 1591

Transducer Calibrator—The Autocal eliminates "recalibration bottle-neck" by automatically performing the calibration of one to twelve pressure transducers.
Allegany Instrument Co., Inc. 1592

Vacuum Thermo Balance—The "Thermo-Gray" automatically records changes in weight as a function of temperature, and changes in weight as a function of time at a constant temperature.
American Instrument Co., Inc. 1593

Wide Band Amplifier—This amplifier is designed to allow complete coverage of the 6–60 Mc range without any adjustments or change in I. F. strips. It will be most useful in those experiments which cover a wide frequency range and need a high gain comparable with tuned amplifiers covering a narrow band.
Arenberg Ultrasonic Laboratory, Inc. 1594

Spectrometer—A direct reading spectrometer with a completely automatic glow tube readout system has been developed.
Baird-Atomic, Inc. 1595

Dial Caliper Gages—The "Quicktest" dial caliper gages precision instruments for the measurement of the thickness of sheet metal, pipe walls, walls of cast specimens, profiles, grooves, rounds, threads, also of foils, cardboard, textiles, lumber rubber, and other applications where precision instruments for measurements are needed is announced.
Bemax Import-Export Co. 1596

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Walk-In Temperature Test—Conrad Model WB-288-705-705 sectional portable walk-in temperature test facility. Range: +350 F to −100 F. Test space size: 6 ft wide, 6 ft 8 in. high, 8 ft. long.
Conrad, Inc. 1597

Pressure Pickup—A new pressure pickup, particularly suited to rocket and engine test stand applications, is available. Known as the Type 4-323, it has been designed for an extremely wide range of gage and absolute pressure measurements.
Consolidated Electrodynamics Corp. 1598

Universal Testing—Development of a new 300-lb capacity universal tester has been announced. This new, motorized instrument greatly increases the working range of the Dillon line of multiflow range universal testers, since past models have been limited to a maximum of 100-lb capacity.
W. C. Dillon & Co., Inc. 1599

Oscilloscope—New Model K-270 dual-channel oscilloscope offers a wide selection of accessory plug-in units for important optional circuits.
Electronic Tube Corp. 1600

Thermostat—New thermostat is particularly useful under corrosive conditions—permits the thermoswitch unit to be easily changed from one process or experiment to another without loss of sensitivity or performance.
Fenwal, Inc. 1601

Viscometer—A new viscometer for accurately measuring and recording the consistency of starch pastes, designated as the "Corn Industries Viscometer" has been developed.
Gaertner Scientific Corp. 1602

Calibrator—The new Model 104, calibrator for calibrating instruments used with resistance type force and pressure cells, rated on a voltage output ratio basis has been announced.
Gilmore Industries, Inc. 1603

Drying Oven—A new constant temperature laboratory oven with temperature range to 200 C (400 F), with shelves adjustable for height every half inch, called Model 10-200-C, has been introduced.
Grieve-Handry Co., Inc. 1604

Power Oscillator—This instrument can be employed as an electronic generator to supply 160 volt amps with less than 1 per cent distortion and a regulation of better than 1 per cent.
The Industrial Test Equipment Co. 1605

Electrometer—The Model 610 electrometer is an all-purpose instrument for measuring d-c voltage, current and resistance over extremely broad ranges. It also serves as a convenient d-c amplifier.
Keithley Instruments, Inc. 1606

Titrator—A new coulometric analyzer for quantitative analysis is announced. It is essentially a titration equipment in which the end point is reached by using a measured quantity (coulombs) of electricity, instead of a measured quantity of standard chemical.
Leeds & Northrup Co. 1607

Soft-Beta Isotopes—The Model 6000 dynacon is a dynamic condenser electrometer designed to accept and measure radioactive carbon-14, tritium, or sulfur-35 samples in the solid, liquid, and gas phases.
Nuclear-Chicago Corp. 1608

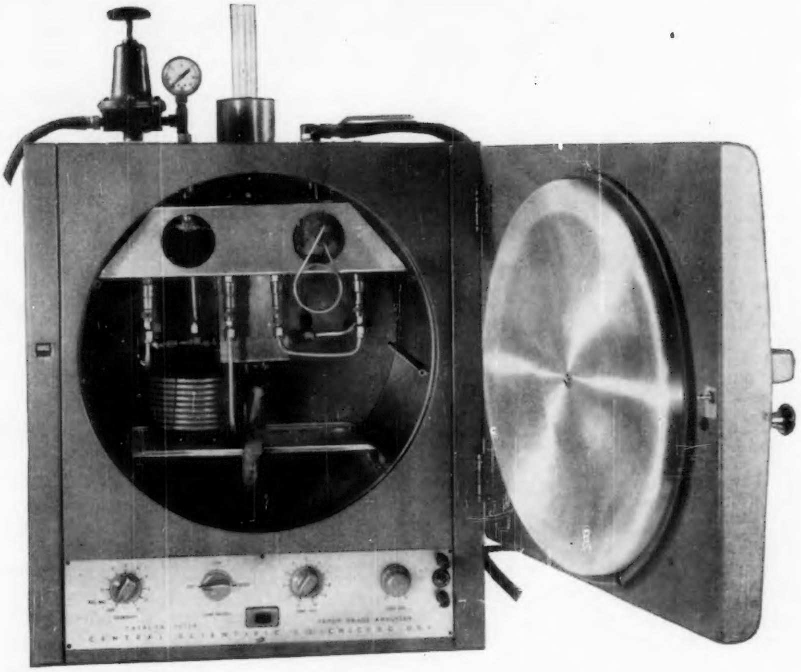
Scaler—A new model instrument that converts any scaler into a proportional counter for precision measurement of radioactivity in prepared samples is offered. It is known as the PCC-10A proportional counter converter.
Nuclear Measurements Corp. 1609

Stress-Strain-Curves—Using a new converter unit, stress-strain curves can now be produced with SR-4 strain gages in combination with an electronic recorder.
Tinius Olsen Testing Machine Co. 1610

Insulation Tester—Available in voltage ranges of 5 kv to 150 kv and in capacities from ½ to 100 kva, a new "K" series of test set features: high power capacity, low waveform distortion, metering directly at high voltage output, a trip-free circuit breaker.
Peschel Electronics, Inc. 1611

Gammalarm—A new warning device makes it safer to use radioactive isotopes in industry and research. Called the Gammalarm, it responds directly to

(*Continued on page 96*)



(Continued from page 94)

radiation at a level as low as 3 MR per hr. $\frac{1}{100}$ of the recognized, safe, permitted dose).
Picker X-ray Corp. 1612

Zone Melting—Zone melting apparatus for preparation and study of pure materials in solid state research is now being manufactured. The device provides the necessary mechanical apparatus for linear motion of heaters of samples.
Research Specialties Co. 1613

Dry Mixer—The Vibra-Pad is a neoprene coated pad mounted on a rugged three-speed vibrator to accommodate the Sepor Microsplitter. These units are used for mixing fine grained materials and obtaining homogeneous splits and microsamples.
Sepor Laboratory Supply 1614

Soil Load-Settlement—A new and compact soils load settlement device called the Levermatic Consolidation Apparatus has been announced.
Soiltest, Inc. 1615

Cylinder Carrier—A new type of concrete cylinder carrier has been introduced. The metal carrier, called the Bristol Carrier, makes it possible for the engineer or technician to carry two concrete cylinders in the field or in the laboratory with safety.
Soiltest, Inc. 1616

Strain Gage—A new concept in the design of unbonded strain gage accelerometers has been developed. The utilization of gas damping, which is incorporated in the Model A501 accelerometer, is the new design feature.
Statham Instruments, Inc. 1617

Chromatography Tank—New paper chromatography apparatus for micro quantities (1 microliter portions) of test solution is announced. The apparatus is simple, inexpensive, durable, and compact. All operations can be carried out in a normal size fume hood, and cleaning and storage problems encountered with larger apparatus are minimized.
Arthur H. Thomas Co. 1618

Tensile Tester—The Model 30LT tensile tester is a pendulum type table model instrument meeting TAPPI, ASTM, and Federal Specifications. It is equipped with the electro-hydraulic drive offering infinitely variable pulling speeds between 2 in. and 20 in. per min.
Thwing-Albert Instrument Co. 1619

Pressure Calibrators—Improved types of precision aneroid and dial type manometers used as portable calibrators of pressure transducers, is announced.
Wallace & Tiernan, Inc. 1619

Temperature Controller—Release of the versatile, direct dialing, Model 71 YSI Thermistemp Temperature Controller is announced.
Yellow Springs Instrument Co., Inc. 1621

INSTRUMENT COMPANY NEWS

Bausch & Lomb Optical Co., Rochester, N. Y.—In a joint statement Carl S. Hallauer president of Bausch & Lomb Optical Co., Rochester, N. Y., and Dr. M. F. Hasler, president of Applied Research Labs., Glendale, Calif., announced a consolidation of the two companies. Subject to the approval of the stockholders of Applied Research Labs., the consolidation became effective on April 8. Thereafter ARL will be operated as a wholly-owned subsidiary known as Applied Research Labs., Inc., a Subsidiary of Bausch & Lomb Optical Company.

Robertshaw-Fulton Controls Co., Phila. 33, Pa.—Announced plans to construct a fifth research and development center to seek out advanced automatic control devices for use in the home and industry, and also to engage in special developmental work under Government contracts. It is to be called the Eastern Research Center and will be built on an 20-acre site located 14 miles from the center of Philadelphia in the town of King of Prussia.

Testing Machines, Inc., Mineola, L. I., N. Y.—Testing Machines, Inc., has moved to 72 Jericho Turnpike, Mineola, Long Island. Here in air-conditioned showrooms and offices and with enlarged facilities for manufacture, repair, maintenance, and calibration, T.M.I. can offer faster and improved service to its many customers. A new department has been opened for the custom designing of new instruments and for the special modification for testing instruments.

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NEWS OF LABORATORIES

Bowser-Morner Testing Labs., Inc., Ohio—R. R. Mowser recently announced the addition of automatic cycling type vibration test equipment to their environmental testing division.

Oliver B. Cannon & Son, Inc., Philadelphia 43, Pa.—Testing and evaluation of paints, in relation to customers' needs, will now be done by Oliver B. Cannon and Son, Inc., at the general office premises of the industrial painting organization. The new "lab" at 5604 Woodland Avenue, replaces one formerly located in Camden, N. J.

Foster D. Snell, Inc., New York, N. Y.—Davis & Bennett, Inc., 194 Front Street, Worcester, Mass., a 35-year old organization of consulting chemists, chemical engineers, and biologists, was recently acquired by Foster D. Snell, Inc., New York, an organization of consulting chemists and chemical engineers.

Personals

(*Continued from page 79*)

John I. Zerbe, formerly research assistant professor, Small Homes Council, University of Illinois, Champaign, is now associated with the National Lumber Manufacturers Assn., Washington, D. C., as wood technologist.

Clarence Zischkau is retiring from the staff of the Central Research Laboratories, American Smelting and Refining Co., South Plainfield, N. J., Mr. Zischkau has represented his company on Committee E-3 on Chemical Analysis of Metals and has been serving for some time as a vice-chairman of this main group. He is a member of the advisory and editorial subcommittees, also has contributed to the activities of a number of the other subgroups including those concerned with non-ferrous metals, sampling, general analytical methods, and precision and accuracy of methods. Mr. Zischkau also has been serving on Committee E-13 on Absorption Spectroscopy and its subcommittee concerned with methods.

Deaths

(*Continued from page 89*)

led in developing methods for utilizing air-photo maps and existing geologic amps to expedite highway engineering. Active in a number of organizations, Mr. Olmstead had been a member of ASTM since 1954. He served on Committee D-18 on Soils for Engineering Purposes and its subcommittees concerned with physical characteristics of soils and special and construction control tests.

Robert K. Thulman, consulting engineer, Silver Spring, Md.; formerly with Federal Housing Authority (February, 1958). Personal member since 1954. Served for a number of years on Committee C-16 on Thermal Insulating Materials.

OTHER SOCIETIES EVENTS

June 1–4—**American Gear Manufacturers Assn.,** 42nd Annual Meeting, The Homestead, Hot Springs, Va.

June 1–6—**National Association of Power Engineers,** National Convention, Ambassador Hotel, Atlantic City, N. J.

June 2–3—**Society of Naval Architects and Marine Engineers,** Spring Meeting, Chamberlain Hotel, Old Point Comfort, Va.

June 2–5—**American Nuclear Society,** Annual Meeting, Statler Hotel, Los Angeles Calif.

June 8–12—**Special Libraries Assn.,** Annual Convention, Hotel Sherman, Chicago, Ill.

June 8–13—**Society of Automotive Engineers, Inc.,** Summer Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

June 9–11—**Edison Electric Institute,** 26th Annual Convention, John Hancock Hall, Boston, Mass.

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June 9–11—**Health Physics Society,** 3rd Annual Meeting, University of California, Berkeley, Calif.

June 9–11—**American Association of Spectrographers,** 9th Annual Symposium on Spectroscopy, Pick-Congress Hotel, Chicago, Ill.

June 9–13—**National Bureau of Standards,** 43rd National Conference on Weights and Measures, Sheraton-Park Hotel, Washington, D. C.

June 9–13—**4th International Automation Congress and Exposition,** Coliseum, New York, N. Y.

June 9–21—**International Organization for Standardization,** Triennial Meeting, Harrogate, England.

June 11–14—**National Society of Professional Engineers,** Annual Meeting, Chase-Park Plaza Hotels, St. Louis, Mo.

June 15–19—**American Society of Mechanical Engineers,** Semiannual Meeting, Statler Hotel, Detroit, Mich.

June 16–20—**American Society for Engineering Education,** Annual Meeting, University of California, Berkeley, Calif.

June 18–28—**International Iron and Steel Meeting,** Liege, Luxembourg, Charleroi, and Brussels.

June 18–29—**Chemical and Petroleum Engineering Exhibition,** Olympia, London, England.

June 22–25—**American Society of Agricultural Engineers,** Annual Meeting, University of California, Santa Barbara, Calif.

June 22–27—**American Institute of Chemical Engineers,** 50th Anniversary Celebration, Bellevue-Stratford, Philadelphia, Pa.

June 22–27—**The Forest Products Research Society,** 12th National Meeting, Hotel Loraine, Madison, Wis.

June 23–25—**American Society of Refrigerating Engineers,** 54th Annual Meeting, Hotel Leamington, Minneapolis, Minn.

June 23–25—**American Society of Heating and Air-Conditioning Engineers,** Semiannual Meeting, Nicollet Hotel, Minneapolis, Minn.

June 23–27—**American Institute of Electrical Engineers,** Summer Meeting, Statler Hotel, Buffalo, N. Y.

June 23–27—**American Society of Civil Engineers,** Multnomah Hotel, Portland, Ore.

June 24–27—**Canadian Gas Assn.,** Annual Meeting, Manoir Richelieu, Murray Bay, P. Q.

June 26–27—**National Association of Exhibit Managers,** Summer Meeting, Hotel Leamington, Minneapolis, Minn.

July 1–16—**International Electrotechnical Commission,** Annual Meeting, Stockholm, Sweden.

July 8–11—**Institute of the Aeronautical Sciences,** Annual Summer Meeting, Ambassador Hotel, Los Angeles, Calif.

July 28–August 1—**Technical Association of the Pulp and Paper Industry,** 13th Engineering Conference, Multnomah Hotel, Portland, Ore.

The Bookshelf

Paper Loading Materials

Technical Assn. of the Pulp and Paper Industry, Monograph Series, No. 19, New York (1958), 132 pp.; $5.

THE latest TAPPI monograph, No. 19, covers loading or filling materials used to make papers more suitable for various uses, particularly in the graphic arts industry. Earliest used fillers were clay, talc, chalk, and the like. Modern fillers are prepared chemicals, such as titanium dioxide, barium sulfate, and many others. Each of the loading materials in current use receives detailed discussion, which will be of value to all paper manufacturers and students in this field.

Pulp and Paper Manufacture Bibliography (1956 and United States Patents (1955–1956).

Technical Assn. Pulp and Paper Industry, New York (1957), 1003 pp.; $10.

TAPPI's 1957 Edition of the bibliography covering literature on pulp and paper manufacture and patents in this field is now available.

The 260 journals from which the bibliography was assembled literally cover the earth. Subject and author index included.

Nickel and Its Alloys

National Bureau of Standards, *Circular 592*, U. S. Government Printing Office, Washington (1958), 90 pp.; 60 cents.

THIS is an extremely informative publication issued February, 1958, covering everything from alloy steels and cast irons to electroless nickel plating. Much new information developed and released since the issuance of *Circular 485* on the same subject in 1950 has been included. The revision includes in some 90 compact pages a review of the literature through 1956 and some 1957 references and unpublished information. Chemical, physical, and mechanical properties, as well as much process information, and a list of references are included in this useful N.B.S. Circular.

Russian-English Glossary of Acoustics and Ultrasonics

Edited by P. Robeson, Jr.; Consultants Bureau, Inc., 227 W. 17th St., New York 11, N. Y.; mimeographed; 192 pp; 8½ by 11; $10.00.

THIS glossary is a compilation of terms and expressions taken from numerous articles on various topics in the field of acoustics, electro-acoustics, and ultrasonics theory. They were taken from several thousand pages of the most recent issues of Soviet physics and engineering journals, especially the *Journal of Acoustics*, the *Journal of Technical Physics*, and *Radio-Engineering*. Also included are many terms found in Russian-texts and English texts which have been translated. The editor has made special effort to emphasize the rapidly growing field of ultrasonics. The glossary concludes with a list of Russian-English equivalents and names commonly found in acoustics and ultrasonics theory.

Protection Against Neutron Radiation up to 30 MEV

National Bureau of Standards *Handbook 63*. U. S. Government Printing Office, Washington 25, D. C. 88 pp.; 40 cents.

Because of their physical properties and biological effects, neutrons present a special type of radiation hazard. This handbook reflects the thinking of The National Committee on Radiation Protection that the recommended limits for maximum permissible dose of ionizing radiations be substantially lowered. In the section on protection against neutron radiation, rules are given which are deemed essential for proper protection. Other chapters cover the present status of physical and biological information, and radiation protection in installation and operation of neutron sources. A list of further references in this important field is appended.

OTS Research Reports

THESE reports, recently made available to the public, can be obtained from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. Order by number.

The Effect of Nitrogen and Vacuum Degassing on the Properties of a Cast Aluminum-Silicon-Magnesium Alloy (Type 356). PB 131351, 75 cents.

Correlation of Literature on the Effect of Testing Temperature on the Mechanical Properties of Wrought Aluminum Base Alloys. PB 131346, $3.

The Effects of Inelastic Action on the Resistance to Various Types of Loads of Ductile Members Made from Various Classes of Metals: Part 7—Inelastic Behavior of Aluminum Alloy I-Beams with Elliptic-Type Web Section Outputs. PB 131556, $1.

Proceedings of the 1955 Sagamore Research Conference: Strength Limitations of Metals. PB 131280, $10.50.

Pitting in Ferrous Systems: An Annotated Bibliography. PB 131006, $3.25.

Development of a Corrosion Resistant Magnesium Alloy: Part 2—Surface Tension Data of Elements. PB 131444, $1.50.

Principles and Application of Heat Treatment for Titanium Alloys. PB 121636, $3.50.

Progress Report on the Salt Corrosion of Titanium Alloys at Elevated Temperature and Stress. PB 121637, $1.50.

Vacuum-Fusion Analysis for Oxygen in Titanium. PB 121638, 75 cents.

Status of High-Strength Steels for the Aircraft Industry. PB 121639, $2.75.

Nonmetallic Ferromagnetic Materials and Devices. PB 131559, $3.75.

Research and Development on Magnetic Films. PB 131557, $1.50. (This work was aimed at expansion of knowledge of ferromagnetic materials and improvement of magnetic cores and memory units.)

Micronic Capacitor. PB 131433, $1.75. (A micronic capacitor is one produced by condensing vaporized metals and dielectrics in alternate layers under high vacuum.)

Development of Sandwich Construction Inorganic Radomes, Part 1. PB 131408, $1.50. (development of a ceramic sandwich radome which would resist high operational skin temperatures)

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Development of Sandwich Construction Inorganic Radomes, Part 2. PB 131406, $1.25.

Photochemical Synthesis of Organic Fluorine Compounds: Part 1. PB 131558, $3. (Organic and organo-metallic fluorine compounds were synthesized with the primary objective of obtaining monomers suitable for polymerization into elastomers, plastics, fluids, and related material of high thermal and chemical stability.)

Fluids, Lubricants, Fuels, and Related Materials: Part 5. PB 131405, $6. (development of hydraulic fluids and jet engine lubricants for use in the range 400 to 700 F)

Development of a Hydrolytically Stable High-Temperature Hydraulic Fluid. PB 131380, $1.75. (Improvement was sought of the hydrolytic stability of silicate-based hydraulic fluids operating in the −65 to 400 F range.)

High-Temperature Hydraulic Swivel Joints. PB 131555, 50 cents. (Flexible plastics, such as Teflon, for seals offer greater developmental possibilities for use at high temperatures than "O" ring-type rubber packings.)

Bulk Compressibility of Polymers at Fabricating Temperatures. PB 131334, 75 cents.

The Branching Reaction in Polymerization of Styrene and Methyl Methacrylate. PB 131094 $1.75.

The Oxidative Degradation of Large Molecules. PB 131384, $1.25.

Oxidative Degradation of Deutero-Polystyrenes. PB 131409, $1.25.

Investigation of Pressure-Sensitive Sealing Tape. PB 131320, $1.25.

Investigation of Shock Waves Developed During Dynamic Tests of Cushioning Materials. PB 131429, 75 cents.

Progress Report on Raw Materials for September, 1957. ORNL-2443, $1.25

Progress Report on Raw Materials for October 1957. ORNL-2451, 75 cents.

The Corrosion of Type 347 Stainless Steel in Boiling Digest Liquors. BMI-1252, $1.25.

AEC Meteorological Information Meeting Feb. 1-2, 1951, TID-10081, $2.50.

Rectifiers. CTR-337, 10 cents (1930-1958).

Paper and Allied Products. CTR-334, 10 cents (1932-1957).

A new free price list of Atomic Energy Commission unclassified research reports for sale by the Office of Technical Services is now available, request AEC Research Reports Price List No. 29 from OTS, U. S. Department of Commerce, Washington 25, D. C.

25th Annual Conference of Doble Clients

Raab Describes Timely Activities of ASTM in Field of Electrical Insulation

The 25th Annual Conference of Doble Clients was held in Boston at the Sheraton Plaza January 27–31, 1958. The conference is sponsored annually by the Doble Engineering Company for representatives of the client firms which use the Doble Engineering service on electrical insulation problems. At this year's meeting, two representatives of ASTM were invited to speak to tell the conference what ASTM means to the electric power industry. E. L. Raab of the General Electric Co., representing ASTM Committee D-9, Subcommittee IV, and F. F. Van Atta of the ASTM Staff shared a 15-min period with Mr. Van Atta speaking first and describing briefly the highlights of many committee activities valuable and useful to the electric power industry. Mr. Raab described more in detail the work of ASTM Committee D-9 on Electrical Insulating Materials. The essence of Mr. Raab's remarks follows.

. . . your company can derive large benefits from participating in the activities of ASTM. Like everything else in life you and your company will benefit in direct ratio to how much you put into it. This is not a one way street. As a society we need the benefit of your operating knowledge and experience as well as an understanding of your problems, both current and anticipated. In turn you will benefit from the discussions and have access to the data accumulated on research projects and the data acquired during the development of test methods and specifications.

Committee D-9 is of particular interest. . . in that it covers the development of methods of sampling and testing, and the formulation of specifications for electrical insulating materials, including research concerning the properties of such materials and products. Specifically this means such materials as insulating varnishes, paints, lacquers, plates, tubes, rods and molded materials, liquid insulation, ceramic products, solid filling and treating compounds, insulating fabrics and papers, mica products, and magnet wire insulation to mention some of the major classifications. In addition it also covers the development of a variety of electrical test methods and a special group studying the effects of nuclear and high energy radiation.

Subcommittee IV covering liquid insulations is of particular interest to me and is the one I am most familiar with. At the moment it covers transformer oil, askarels, and cable oils, but we believe that in the very near future it will also actively cover dielectric gases, silicone liquids for dielectric application and any new types of dielectric liquids which may be developed.

A new group . . . is embarking on the study of a stability test for liquid impregnated paper. This group will undoubtedly cover both cable and transformer oil in this respect.

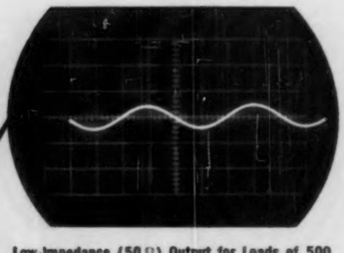
Of particular interest . . . is the work which has been going on jointly with the American Institute of Electrical Engineers covering the development of suitable field test methods and the issuance of two guides—one for the Maintenance of Transformer Oil in the Field, and a more recent one—the Maintenance of Transformer Askarels in the Field.

The meetings of D-9, Subcommittee IV, are very informal and the free discussion and interchange of ideas is encouraged. It is difficult to see how you or your company can afford not to participate in this activity. . . .

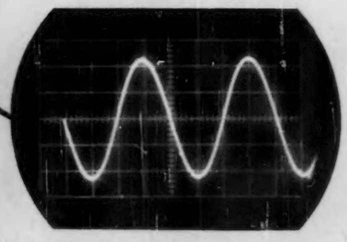
- Sine- and square-wave outputs
- Wide frequency range
- Readily swept with G-R Dial Drives
- Small size
- Fast responding AVC
- Calibrated output control
- Output constant with frequency
- High output
- Precision frequency control
- Compact and rugged
- Inexpensive

3 in 1

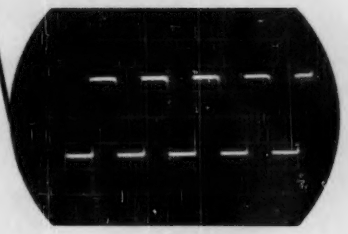
Type 1210-C Unit R-C Oscillator, $180.00



Low-Impedance (50 Ω) Output for Loads of 500 Ohms and Higher: No-load output is 0-7 v, constant to within ±1 db up to 200 kc; no-load distortion less than 1% from 200 c to 10 kc, less than 1.5% over entire frequency range; hum at least 60 db below output-voltage level.



High-Impedance (12.5 KΩ) Output for Loads of 10 Kilohms and Higher: No-load output is 0-45 v, constant to within ±1 db from 200 c to 150 kc; no-load distortion less than 5% from 200 c to 200 kc (distortion reduced under load); hum at least 50 db below maximum output level.



Square-Wave (2,500 Ω) Output: 0-30v peak to peak; rise time approximately ½ μ sec; overshoot approximately 1%; hum at least 60 db below output-voltage level.

The NEW General Radio 1210-C Unit Oscillator is the only oscillator in its price range to offer three separate output systems. Square waves and high- or low-impedance sine waves are yours at a turn of a knob.

This oscillator is unmatched in its class for all-around versatility. In addition to its usefulness as a source of sine and square waves for work at audio, ultrasonic, and low radio frequencies, the 1210-C can be employed as a modulator for r-f oscillators, and as a trigger for pulse generators.

Specifically designed for this instrument are two accessory Synchronous-Dial Drives that readily attach to the oscillator frequency control, allowing automatic plotting and display of amplitude frequency characteristics. Laborious point-by-point measurements are eliminated by this inexpensive sweep-driven oscillator system used with conventional recording equipment.

Frequency Range: 20-500,000 cycles in 5 ranges.

Frequency Controls: Range selection switch and 4-inch precision gear-driven dial. Dial has two scales, 2-20 and 50-500, and is geared to a slow-motion knob that covers each decade in about 4½ turns.

Frequency Accuracy: ±3%.

Output Control: Logarithmic, calibrated 0-50 db.

Power Requirements: 6.3 v a c or d c at 1 amp; 300 v d c at 50 ma; Type 1203-B Unit Power Supply ($40.) recommended for operation from 115 v, 50-60 cycles.

Fastening Power Supply: The Type 1210-C Oscillator can be firmly and permanently attached to any G-R Unit Power Supply by using the two stainless-steel locking strips supplied with oscillator.

ACCESSORIES

Type 908-P1 Synchronous Dial Drive, sweeps through one frequency decade in 50 sec; 908-P2 takes 6⅔ sec per decade, $29.00 for either.

Type 480-P4U3 Relay-rack Panel for mounting both 1210-C Oscillator and 1203-B Power Supply in one panel, $10.85

Type 1210-P1 Detector and Discriminator provides necessary voltages for convenient oscillograph display, $80.00

GENERAL RADIO Company

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2-Year Warranty

WE SELL DIRECT. Our District Sales Offices are staffed by engineers especially trained to help you in the selection of instruments and measuring systems best suited to your needs. We welcome your inquiries — will help solve your problems.

FOR FURTHER INFORMATION CIRCLE 943 ON READER SERVICE CARD